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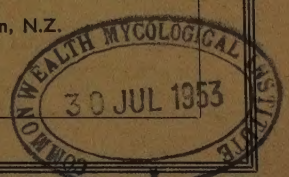

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NOTICES

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"CLOUD" OR VASCULAR BROWNING IN TOMATOES

II. SOME CHEMICAL CHARACTERISTICS OF PLANT AND SOIL IN RELATION TO SUSCEPTIBILITY TO "CLOUD"

By E. B. KIDSON* and D. J. STANTON, Cawthron Institute, Nelson.

(*Received for publication, 2 April 1953*)

Summary

Cloud has been found to be associated with a low dry-matter content of the fruit and leaves.

Treatments which increase cloud have been shown to decrease the dry-matter in the fruit and leaves and vice versa.

The tentative conclusion is drawn that cloud is the result of an abnormally low content of organic matter in the fruit and may be due either to an excessive water uptake or to reduced photosynthesis under reduced light or to both these causes.

It is suggested that the beneficial effect of heavy dressings of potash and nitrogenous fertilizers may be due to their effect on water uptake by the plant.

Measures for the control of the disorder are suggested.

INTRODUCTION

A previous paper in this series gives a description of the form of blotchy-ripening known as "cloud", and describes conditions which have been found to affect the susceptibility of the plant to the disorder[1]. This paper discusses results obtained in an attempt to determine whether cloud is associated with a mineral deficiency or excess, or some other abnormality of chemical composition.

MINERAL COMPOSITION OF FRUIT AND LEAVES IN RELATION TO CLOUD

Fruit

Attempts to find consistent differences in mineral composition between cloud fruit and healthy fruit have so far failed. Analyses have revealed no apparent deficiency of a major element. Table I shows typical nitrogen, phosphate, potash, sulphur and calcium figures for fruits from experimental plots in the season 1949-50. Cloud fruits and apparently normal fruits off the same plots are compared. Figures are also given for a plot only slightly affected by cloud. The variety used for the glasshouse plots (A, B and C) was Potentate. M.E. 8 was an outdoor plot with the variety Kondine.

* Officer of the Department of Scientific and Industrial Research.

TABLE 1. MINERAL COMPOSITION OF CLOUD AND NORMAL TOMATOES

(Expressed as percentage of dry-matter)

Plot No.	Sample	P_2O_5	N	K_2O	SO_4	CaO
A21 + 22	Normal	1.00	2.14	5.84	1.32	0.22
A21 + 22	Cloud	1.04	2.04	6.12	1.32	0.25
B 18	Normal	1.07	2.35	6.34	1.26	0.18
B 18	Cloud	1.18	2.12	6.59	1.26	0.20
C 1	Normal	1.04	2.21	6.17	1.22	0.24
C 2	Normal	0.97	1.96	5.56	1.27	0.27
C 2	Cloud	0.93	1.76	5.64	1.18	0.28
M.E. 8	Normal	0.85	2.09	4.19	—	0.19
M.E. 8	Cloud	0.96	2.52	4.56	—	0.17

NOTE:—Plots A 21 and 22 and B 18 had a moderate amount of cloud over the whole season. Plot C 2 was badly affected. Plot C 1 was almost free from the disorder. The outdoor plot M.E. 8 had cloud only in the early pickings.

It will be seen that no very distinct differences between cloud and normal fruits in phosphate, nitrogen, potash, sulphur or calcium were found. Phosphate and potash in the dry-matter of cloud fruit were on the whole a little higher than in cloud-free fruit. On the fresh-weight basis the reverse was true for potash, while differences were negligible for phosphate. The general level of potash and phosphate appears to indicate an adequate supply of both. In glasshouse plants there were indications of a slightly lower nitrogen status in cloud fruits than in corresponding fruits unaffected by the disorder. However cloud was absent in fruit with nitrogen as low as 1.96 per cent. Sulphur in all samples was very high, but the figures showed no correlation with the presence of cloud.

A limited number of analyses has given no indication that the magnesium, chlorine or iron contents of the fruit are related to cloud.

Leaves

As for fruit, no correlation has yet been found between the level of mineral constituents in the foliage and the presence of cloud. Analyses of leaves from plots showing varying degrees of susceptibility to cloud are presented in Table 2. The samples consisted of the leaf above the second bunch from a number of plants typical of the plot. The main mid-ribs were removed. At this stage the plants were about six feet in height with some six trusses formed.

It will be seen from Table 2 that cloud was not shown to be consistently related to any particular level of any of these elements. There was no indication that susceptibility of the plant to the disorder was associated with a shortage of potash. Nor do the data suggest that cloud can be attributed to a direct shortage of nitrogen in the plant. These conclusions are supported by figures obtained for young leaves.

TABLE 2. MINERAL COMPOSITION OF TOMATO LEAVES IN RELATION TO CLOUD: SAMPLED 4.12.50

(Calculated on the dry-matter basis)

Plot No.	Treatment	Cloud	CaO (%)	MgO (%)	K_2O (%)	N (%)	Mn (p.p.m.)	Cl (%)	P_2O_5 (%)
B 4	F+ Extra N	Trace	10.98	3.13	2.90	3.09	1060	1.49	1.05
B12	F+ Extra N + K	Trace	11.71	3.46	2.23	2.84	560	3.51	—
B 3	No Fertiliser	Slight	10.91	3.36	1.48	2.41	500	4.89	0.92
B10	F	Slight to Medium	11.44	3.49	2.20	2.72	630	3.39	0.96
B 6	F+ Extra water Extra N + K	Medium	11.68	2.85	2.91	2.98	800	3.01	1.08
B 8	F+ Extra water	Bad	11.68	2.91	2.76	2.67	480	3.32	—
C 8	F+ Glucose+ Extra N + K	Nil	10.97	294	3.25	2.10	1000	3.69	1.02
C 6	F+ Glucose+ + Extra K	Slight	11.65	3.39	2.04	2.45	820	3.54	1.06
C10	F	Medium	11.44	3.42	1.90	2.36	670	3.11	0.91
C12	F+ Glucose	Bad	11.50	3.53	1.90	2.34	630	3.05	1.06

NOTE:—F represents standard fertilizer.

Trace elements other than manganese have not been estimated in view of the fact that Fe, B, Mo, and Zn used as sprays were not effective in controlling cloud, and that the disorder occurred in plants supplied with a diversity of organic manures.

AVAILABLE SOIL NITROGEN IN RELATION TO CLOUD

In view of the beneficial effect of heavy soil dressings of nitrogen fertilizers[1], an examination was made of the available nitrogen in plots varying in susceptibility to cloud. (Table 3).

From Table 3 it can be seen that high available nitrogen in the soil was associated with relative freedom from cloud on the normal-watering plots B4, B12 and C8. On the other hand, in Plot B6 with extra water, an appreciable amount of cloud was produced on a soil of relatively high available nitrogen content. Plot C6 with very low available nitrogen had only slight cloud and Plot B3 where the nitrogen status was also comparatively low was no more affected by the disorder than the standard plot. Though extra nitrogen applications have proved beneficial there appears to be no definite correlation between total available nitrogen or between nitrate or ammonia content of the soil and the incidence of cloud.

TABLE 3. AVAILABLE SOIL NITROGEN IN RELATION TO CLOUD

(Expressed as p.p.m. of nitrate plus ammonia nitrogen in moisture-free soil)

Plot No.	Treatment	Cloud	Available soil nitrogen on date sampled			
			5.9.50	7.11.50	30.11.50	10.1.51
B 4	F+ Extra N	Trace	97	210	260	301
B12	F+ Extra N + K	Trace	51	220	300	261
B 3	No Fertiliser	Slight	42	63	38	17
B10	F	Slight to Medium	50	84	110	76
B 6	F+ Extra Water+ Extra N + K	Medium	49	163	232	196
B 8	F+ Extra Water	Bad	62	84	108	68
			7.9.50	6.11.50	5.12.50	15.1.51
C 8	F+ Glucose+ Extra N + K	Nil	42	76	693	280
C 6	F+ Glucose+ Extra K	Slight	39	—	28	32
C10	F	Medium	35	53	35	72
C 4	F+ Glucose	Bad	58	56	45	37

Samples were taken to a 0-9-in. depth half in the rows and half between the rows.

Extra nitrogen was applied in mid-October and on 8 November, 23 November and 28 December.

DRY-MATTER CONTENT OF FRUIT AND LEAVES IN RELATION TO CLOUD

Fruit

Though it has not been possible to correlate differences in mineral content with susceptibility to cloud, a large and comprehensive series of analyses has shown that a low dry-matter content is a characteristic of cloud fruit, particularly of the fruit-wall.

Typical dry-matter figures for cloud and healthy fruits from the experimental plots (season 1949/50) are given in Table 4 below.

Dry-matter was estimated by drying the samples at 100° C. Though changes in the organic constituents are known to take place at this temperature, the method was considered sufficiently accurate for the purpose. In Table 4 figures represent the percentage dry-matter of the whole fruit.

It will be seen that cloud fruits were consistently lower in dry-matter than healthy fruits from the same plot (Table 4). Healthy fruits averaged 5.5 per cent of dry-matter with a range of 4.9 to 6.5, while cloud fruit averaged 4.4 per cent, with a range of 3.9 to 5.2. It may be pointed out that all these plots except A20 were affected by the disorder to some extent, and some fruit recorded as healthy might have been on the borderline of susceptibility to cloud.

TABLE 4. PERCENTAGES OF DRY MATTER IN CLOUD-FREE AND AFFECTED FRUITS: SEASON 1949/50

Plot	No Cloud	Cloud	Date
C 1	6.1	—	12.12.49
C 1	5.9	—	20.2.50
A 20	5.8	—	12.12.49
C 2	5.0	4.1	12.12.49
C 2	5.7	4.7	20.2.50
C 3	5.3	4.5	18.1.50
C 3	5.3	4.6	20.2.50
A 9	5.2	4.6	18.1.50
A 16	6.5	5.0	23.1.50
A 18	5.2	4.2	18.1.50
A 21 & 22	6.2	5.0	9.1.50
B 2	5.2	4.7	18.1.50
B 3	5.7	5.2	9.1.50
B 5	5.8	4.6	9.1.50
B 6	5.3	3.9	9.1.50
B 7 & 8	5.3	4.1	20.2.50
B 9 & 10	5.5	3.9	20.2.50
B 10	5.3	4.7	9.1.50
B 10	4.9	4.6	18.1.50
B 11 & 12	5.4	4.1	20.2.50
B 18	5.3	4.3	18.1.50
B 18	4.9	4.0	23.1.50
House A	—	4.1	12.12.49
House A Composite	—	4.7	9.1.50
House B	—	4.0	12.12.49
House B Composite	—	4.6	9.1.50
Average	5.5	4.4	
Range	4.9 - 6.5	3.9 - 5.2	
Probable Error of Means	0.05	0.05	

Comparatively high figures for dry-matter (6.6, 7.0 per cent) were obtained from samples of fruit with blossom-end rot, which field observations have shown to increase with treatments which have been effective in reducing cloud.

Cloud fruits when they first ripen have green tissue in the affected areas. Analyses at different stages of development have shown that as the fruit ripens, it tends to decrease in dry-matter and the presence of immature tissues is therefore not an explanation of the low dry-matter associated with the disorder.

A relationship between low dry-matter and cloud has been confirmed by many later analyses. A comparison of the minerals in cloud and healthy fruits has led to the conclusion that differences in dry-matter are due primarily to differences in the level of organic constituents.

Effect of Soil Treatment on the Dry-matter and Carbohydrate Content of Fruit

In Table 5 are given figures for dry-matter and total carbohydrate in fruit from plots showing varying susceptibility to cloud under different soil treatments. In each case the fruit was sampled at the mature-green stage. The fruit wall only was taken for analysis, a longitudinal slice excluding the seeds. Cloud fruits were avoided as much as possible during sampling and necrotic tissue was absent from the samples except for occasional traces.

An approximate estimation of total carbohydrate was made on the fresh fruit by breaking down the sample in a blender, hydrolysing with hydrochloric acid on a water-bath for three to four hours and estimating the total reducing sugars. Results in Table 5 are expressed as percentage of the fresh weight. Total carbohydrate has been calculated as glucose. Cloud is expressed as the average number of cloud fruits per 10 plants recorded on the plot to the date of the last sampling. In this, and all following tables, F represents the standard fertilizer treatment, N represents a mixture of equal quantities of sulphate of ammonia and nitrate of soda, and K muriate of potash. Quantities of extra N and K are expressed as ounces of fertilizer per square yard applied during the growing season. All plots were steamed except where specified. Details of the standard fertilizer and glucose treatment are given in Part I [1] of this series.

The results in Table 5 again indicate a correlation between low dry-matter and cloud. Treatments which brought about an increase in cloud were associated with a decrease in dry-matter and total carbohydrate. The heavy watering plot B8 averaged 4.4 per cent and 1.8 per cent for these constituents compared with 5.2 and 2.3 per cent for the control plot B10. Fruit on the glucose plot C4 showed a similar decrease compared with those on the standard plot C10. The unsterilized plots A20 and A19, seldom affected by more than slight traces of cloud, had 7.0 and 6.3 per cent of dry-matter, appreciably more than the neighbouring steamed plot A21 (5.5 per cent) where cloud was present.

On the other hand, a rise in the level of dry-matter and total carbohydrate was indicated as a result of treatments which decreased the susceptibility to cloud. This could be seen where extra potash or nitrogen or potash plus nitrogen had proved beneficial when superimposed on the standard treatment (B4, B12), the heavy-watering treatment (B6) and the glucose treatment (C8, C6).

Amounts of total, coagulable and soluble nitrogen in samples listed in Table 5 could not be correlated with the susceptibility of the plants to cloud.

Cloud was very bad during the 1951/52 season, particularly in the December pickings. In Table 6 are given figures for dry-matter in fruits from plots with different soil treatments. Fruits were picked at the mature-green stage and a slice of the peripheral wall only used for the estimation. The cloud figures in the table represent the average number of cloud fruits per 10 plants to the time of sampling.

TABLE 5. EFFECT OF SOIL TREATMENT ON THE DRY-MATTER AND TOTAL CARBOHYDRATE CONTENT OF TOMATO FRUITS: SEASON 1950/51

Plot No.	Treatment	Cloud	23-27 November		11-13 December		27 December -4 Jan.		Averages	
			Dry matter (%)	Carbo-hydrate (%)	Dry matter (%)	Carbo-hydrate (%)	Dry matter (%)	Carbo-hydrate (%)	Dry matter (%)	Carbo-hydrate (%)
A 20	F Unsterilized	0					7.0	3.5		
A 19	F Unsterilized. Cocoa Husks	0					6.3	3.1		
A 21	F Steamed	4.4					5.5	2.5		
B 4	F + 12 oz. N	0.2	7.0	3.6	6.3	3.0	6.5	3.0	6.6	3.2
B 12	F + 12 oz. N + 8 oz. K	0.2	5.9	2.8	6.2	2.8	5.9	2.5	6.0	2.7
B 3	No fertilizer	1.4	5.9	3.2	5.6	2.3	4.9	2.1	5.5	2.5
B 10	F	4.2	5.6	2.6	4.9	2.1	5.2	2.2	5.2	2.3
B 6	F + 12 oz. N + 8 oz. K + Extra water	18.8	5.0	2.3	5.1	2.1	4.9	2.2	5.0	2.2
B 8	F + Extra water	58.5	4.6	2.0	4.2	1.6	4.4	1.9	4.4	1.8
C 8	F + 16 oz. N + 16 ozs. K + Glucose	0	5.6	2.7	5.8	2.5			5.7	2.6
C 6	F + 16 oz. K + Glucose	2.5	5.4	2.1	5.6	2.4			5.5	2.3
C 10	F	9.3	5.4	2.4	5.5	2.4			5.5	2.4
C 4	F + Glucose	36.7	4.7	1.9	5.0	1.9			4.9	1.9

TABLE 6. EFFECT OF SOIL TREATMENT ON THE DRY-MATTER CONTENT OF TOMATO FRUITS: SEASON 1951/52

Plot No.	Treatment	Dry matter (%)	Cloud
B 12	F + 4.2 oz. N + 8 oz. K	5.8	14*
B 2	F + 4.5 oz. Dried blood (before planting) + 4.2 oz. N	5.6	39*
B 4	F + 8.4 oz. N + Extra water	5.0	44
B 10	F	5.2	46
B 6	F + 4.2 oz. N + 8 oz. K + Extra water	5.0	61
B 8	F + Extra water	4.9	64
B 3	P + K only + Extra water	4.9	97
C 8 & 9	F + 6.8 oz. sulphate of ammonia	5.4	30*
C 4 & 7	F + 11.2 oz. Dried blood	5.1	58
C 3 & 10	F (all nitrogen as ammonium sulphate)	5.0	76
C 1 & 6	P + K only	4.9	77

* These plots had no cloud at the time of sampling.

It will be seen (Table 6) that figures of 4.9 to 5.2 were obtained for plots still showing cloud and 5.4 to 5.8 for plots where the disorder has disappeared with advancing season (Plots B12, B2, C8 and 9). All extra-water plots were badly affected by cloud and though some beneficial effect was shown in the cloud recordings from the use of extra nitrogen or nitrogen plus potash with extra water this was not reflected in the dry-matter content of the fruits sampled. The lowered incidence of cloud brought about by the use of extra nitrogen or extra nitrogen plus potash with standard watering was however associated with an increased content of dry-matter (Plots B12, B2, C8 and 9).

Analyses have indicated that on cloud-susceptible plants fruit may have an abnormally low dry-matter content from a very early stage. Fruit of approximately half inch diameter showed a lower dry-matter content on a badly-affected heavy-watering plot (7.7 per cent) than on plots which were relatively free from the disorder (8.6 per cent). Comparable figures for fruit three-to-four weeks from maturity were 4.8 per cent and 6.2 per cent.

Effect of Soil Treatment on the Dry-matter Content of Leaves.

Leaves tested also showed a correlation between dry-matter content and cloud-susceptibility on different soil treatments, (Table 7). The old leaf was taken above the second bunch and the young leaf, fifth from the top of each plant.

The main mid-ribs were removed and the leaves dried at 100° c.

It will be seen that both young and old leaves varied in dry-matter content and gave indications of a low status in cloud-susceptible plants.

TABLE 7. EFFECT OF SOIL TREATMENT ON THE DRY-MATTER CONTENT OF LEAVES: SAMPLED 5.12.50

Plot No.	Treatment	Cloud	Old Leaf (%)	Young Leaf (%)
B 4	F + 12 oz. N	Trace	10.7	13.5
B 12	F + 12 oz. N + 8 oz. K	Trace	—	12.6
B 3	No fertilizer	Slight	10.6	12.9
B 10	F	Slight to Medium	9.9	11.8
B 6	F + 12 oz. N + 8 oz. K + Extra water	Medium	8.6	10.6
B 8	F + Extra water	Bad	7.9	10.7

Effect of Soil Moisture and Fertilizer on the Dry-matter Content of Fruit.

In order to obtain confirmatory evidence of the influence of the soil-moisture content on the dry-matter of the fruit, a pot experiment was carried out under glass using heavy and light rates of watering, with and without a liberal dressing of artificial fertilizer.

Soil of the same type as that used in the glasshouse experiments was mixed with well-rotted hay compost, giving a mixture with a loss on ignition of 12 per cent. Tins of four-gallon capacity were filled with this soil mixed with four ounces of cocoa husks per tin. Fertilizer was applied to half the tins. This consisted of a mixture of: superphosphate, two parts; muriate of potash, two parts; and sulphate of ammonia, one part, at the rate of four ounces per tin mixed thoroughly with the soil. The tins were then sterilized with chloropicrin, moistened, and left for seven weeks. On 21 August they were planted with the Potentate variety, one plant to each tin. The treatments were as follows:

I: No fertilizer, light watering.
II: No fertilizer, heavy watering.
III: Fertilizer, light watering.
IV: Fertilizer, heavy watering.

In the heavy-watering tins the soil was kept near saturation continuously, sufficient water being given so that some free water was present in the bottom of the tin. The light-watering tins were watered first once a week and then, when necessary, twice a week.

On 18 October, 6 g. dried blood per tin was worked into the surface of all tins.

A month after planting, the effect of heavy watering was showing in increased growth in Treatment II (without fertilizer). Where mineral fertilizer had been applied, the increase in growth brought about by heavy watering was small. Throughout the season Treatment II was strikingly different from the others in that the plants were taller and thicker and the crop heavier. The fruit tended to be large and uneven in shape. Fig. 1 shows the type of growth produced by the four treatments by 24 October.

FIG. 1.—Tomato plants nine weeks after planting:
(I) No fertilizer, light watering.
(II) No fertilizer, heavy watering.
(III) Fertilizer, light watering.
(IV) Fertilizer, heavy watering.

In late October extra ventilators were opened and the tops of the plants began to be affected by fumes of 2-4D which had been used in the neighbourhood as a weed-killer some months previously. The experiment, however, was continued and observations were made on the early fruit which showed no effect of the hormone. Dry-matter of the fruit was determined on ripening. The yield per plant included all fruit on the plant. The results are given in Table 8. Dry-matter was estimated on the whole fruit.

TABLE 8. EFFECT OF HEAVY WATERING AND FERTILIZER ON DRY-MATTER OF FRUIT

Treatment	No. of plants	Average yield per plant (g.)	Probable error of mean	Average dry-matter of ripe fruit (%)	Probable error of mean	Cloud
I. No Fertilizer, light watering	5	985	79	8.8	0.2	None
II. No Fertilizer, heavy watering	4	2842	176	5.2	0.1	Some
III. Fertilizer, light watering	5	671	35	9.1	0.4	None
IV. Fertilizer, heavy watering	6	1098	44	7.6	0.1	None

The effect of heavy-watering on the no-fertilizer pots is very noticeable (II, Table 8). There was a very greatly increased growth and yield. The fruit was of low dry-matter content averaging 5.2 per cent compared with 8.8 per cent for the light-watering pots without fertilizer. Three of the four plants developed cloud in Treatment II, the only ones in the experiment to do so. It will be seen from the data for Treatment IV that in the presence of four ounces of fertilizer per pot the effect of heavy-watering was much reduced. The yield of fruit was less than half that given in Treatment II and the dry-matter was as high as 7.6 per cent. Light-watering treatments gave the highest percentage of dry-matter. The experiment was duplicated in a cooler part of the glasshouse under much reduced sunshine. The fruit ripened more slowly. As before, the heavily-watered pots without fertilizer produced fruit of the lowest dry-matter content and one of the pots in this treatment was the only one in the series to develop cloud. The dry-matter did not rise as high with other treatments as in the unshaded pots.

Traces of blossom-end rot occurred on all treatments in the unshaded plants except Treatment II. The amount, however, was small, and many plants had none. It was not consistently related to high dry-matter content, light watering plants producing fruit of up to 9–10 per cent of dry-matter which were free from the disorder.

Effect of Leaf Area on the Dry-matter and Carbohydrate Content of the Fruit.

In Table 9 figures for dry-matter and total carbohydrate are given for plots with severe pruning and defoliation and with light pruning. In Plot A25 an attempt was made to reduce available carbohydrate by reducing the active area and in A27 the opposite effect was sought. Cloud is expressed as average number of cloud fruits per 10 plants to the date of sampling.

TABLE 9. EFFECT OF LEAF AREA ON THE DRY-MATTER AND TOTAL CARBOHYDRATE CONTENT OF THE FRUIT WALL: SAMPLED 8.1.50

Plot No.	Treatment	Cloud	Dry Matter	Total Carbohydrate as Glucose
A 25	Heavy pruning and defoliation	5.6	4.7	2.0
A 26	Normal pruning	3.3	6.0	2.7
A 27	Light pruning. Much extra foliage	20.0	5.1	2.3

It will be seen that severe pruning and defoliation resulted in fruit of a low dry-matter content (A25). There is also a tendency towards the same effect with excess foliage (A27). It might have been expected from previous results that A25 with the low figure of 4.7 per cent dry-matter would have had more cloud than A27 with 5.1 per cent.

Discussion

So far no mineral deficiencies in cloud-susceptible plants have been detected by analysis. The possibility that cloud may be caused by injury from a toxic level of some element in the soil seems remote. Cloud plants usually produce vigorous growth which does not suggest such an explanation. Also, the disorder has occurred on new as well as old glasshouse soils, on different soil types and with different fertilizer treatments.

Though chemical analysis has not indicated a mineral deficiency, certain mineral salts have been effective in reducing cloud, particularly when applied to the soil at frequent intervals. Nitrogen fertilizers, muriate of potash and calcium chloride have all been used with success in this way. That these salts counteracted a mineral deficiency in the plant is unlikely. Calcium was very high in all glasshouse plants and the potash in the fruit was considerably higher on the dry-matter basis than has been found in healthy outdoor fruit. Though it is hard to define a normal figure for nitrogen in the plant, it may be pointed out that certain plots with low soil-nitrogen, reflected in both leaves and fruit, have produced crops relatively free from the disorder. Also, in a bad season, nitrogen up to three times the amount calculated for a yield of 60 tons per acre of apparently normal fruit reduced cloud but by no means eliminated it.

The conclusion seems logical that these mineral salts have a secondary effect on the plant in the control of the disorder.

Cloud-susceptible plants have an abnormally low percentage of total organic matter in the fruit and leaves. This may be due to reduced photosynthetic activity or adverse conditions for translocation of carbohydrates. On the other hand, it may be due to an acceleration of growth for which the carbohydrate supply is inadequate.

Observations have shown that certain conditions which reduce light are conducive to cloud. A wet season with a long succession of sunless days has a very harmful effect. It has frequently been noticed that glasshouse plants receiving partial shade from some outside source are affected more than plants receiving full sunlight The fact that glasshouse tomatoes have more cloud than outdoor tomatoes may be related to reduced light under glass and shorter hours of sunshine in the early part of the season.

The disorder appears to be associated with the cooler temperatures of spring and autumn and spells of wet weather, and to be less prevalent during the heat of mid-summer.

It has been found that other conditions being equal, excessive watering has been a very potent factor in the production of cloud. Many of the treatments affecting cloud can be shown to affect the moisture content of the soil or the ability of the plant to take up water. Wet weather reduces the loss of soil moisture by evaporation and transpiration under glass, and the same applies to shading and to cool temperatures in spring and autumn.

Soil moisture determinations have shown that two standard steamed plots normally associated with better fruit-quality than others were consistently drier throughout the September-November period. Plots

treated with fumigants such as chloropicrin had a more open texture and held less water than neighbouring steamed plots and were less badly affected by cloud in a bad season.

Mineral salts applied frequently throughout the season may be beneficial in that they reduce water intake by raising the osmotic pressure of the aqueous solution available to the roots. In certain cases the mineral salts have been found to cause damage to the surface roots. The possibility that there may be certain non-osmotic effects of fertilizer salts on the roots, due to changes brought about in the permeability of the cells must not be overlooked. It might be expected that there would be an increase or decrease in water-absorption according to the particular salts present and their concentration.

The effect of mineral fertilizer in preventing stimulation of growth by heavy watering is well illustrated by the pot experiment. Here the effect of heavy watering on growth and dry-matter content was almost eliminated by the use of four ounces per four-gallon tin of mineral fertilizer.

Glucose applied to the soil has had a cloud-inducing effect almost as striking as that of heavy watering and the type of plant produced has had similar characteristics of heavy growth and low dry-matter. Glucose-treated plants showed no signs of root injury. There was a tendency towards the production of thicker roots than with the standard treatment. The stimulating effect on growth may be due to increased root activity and water-uptake associated with an increased supply of glucose to the roots as found by Went[2].

If soluble salts in the soil can have some action in regulating water-intake of the roots as experiments suggest, the combination of nitrogen and other elements in organic form during the decomposition of glucose may result in an increased water uptake. This last explanation might apply to the deterioration of fruit quality found with raw organic manures as opposed to well-rotted ones. It is possible, too, that organic compounds are present which stimulate root activity. The water available to the plant may also be affected by an increased water-holding capacity of the soil and an increased root development in the presence of bulky organic manures.

CONCLUSION

As a result of these investigations, the tentative conclusion is drawn that cloud is due to an inadequate supply of organic constituents in the fruit. The disorder may be primarily due to excess water intake by the plants or to decreased photosynthesis under reduced light or to both these causes. No suggestion is made as to how the necrotic tissue is finally produced.

CONTROL

Under local conditions, cloud may be very easily induced by excessive watering, and a careful regulation of the water supply is the first essential in controlling the disorder. Measures for ensuring an adequate but not excessive water uptake by the plant will obviously depend on the season. Experienced growers will generally be able to recognise the heavy type of growth usually associated with cloud. If such growth symptoms appear, steps should be taken to reduce watering, to accelerate loss of moisture from the soil and to steady growth by any other

possible means. Under weather conditions particularly conducive to cloud the use of extra soil dressings of mineral fertilizers such as potash and inorganic nitrogen compounds may be the most effective method of reducing susceptibility to the disorder. All corrective measures should be used with care as they may lead to the formation of blossom-end rot and other symptoms of water shortage.

Acknowledgements

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References

1. Kidson, E. B. and Stanton, D. J., 1953: *N.Z. J. Sci. Tech. 34*: 521-30.
2. Went, F. W., 1944: *Amer. J. Bot. 31*: 597.

ZINC DEFICIENCY IN PEACHES AND NECTARINES

By E. G. Bollard, Fruit Research Station, Department of Scientific and Industrial Research, Auckland

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Summary

The occurrence of zinc deficiency in peach and nectarine trees in Central Otago is recorded. Symptoms consist of leaf chlorosis, reduction in leaf size, rosetting and die-back of leaders. When leaf chlorosis is the only symptom, confusion with manganese deficiency is possible. Foliage sprays of 3 lb. zinc sulphate mixed with 4 lb. hydrated lime in 50 gal. water largely rectified the disorder.

Introduction

Zinc deficiency of pear trees has recently been shown (Bollard, 1953) to be present in the Alexandra district. Further work has now revealed that this deficiency also affects peach and nectarine trees in Central Otago. Mature Muir and Royal George peach, and Goldmine and Hunt's Tawny nectarine trees growing in a sandy loam, pH 6.6–7.4, were affected.

Symptoms

In mildly affected trees intervenal leaf chlorosis (Fig. 1) is the only visible symptom, but in more severely affected trees other symptoms accompany this chlorosis. These include smaller foliage, rosettes of leaves due to lack of shoot extension, failure of buds to break, and, in the most severe instances, die-back of leaders. (Fig. 2). Symptom development within a tree may be irregular—one leader may show severe die-back, while another may exhibit foliar chlorosis only. (Fig. 3).

Foliar chlorosis associated with this deficiency is similar to that caused by manganese deficiency. (Fig. 4). In instances such as that illustrated it is possible to distinguish the two disorders by the chlorotic pattern, but in practice, instances occur where visual differentiation of the two chloroses is not possible. As some zinc-deficient peach trees show leaf chlorosis as their only symptom, it is sometimes impossible to distinguish visually manganese and zinc deficiencies.

Field Trials

On 19 October, 1950, manganese, iron and magnesium sprays were applied to separate plots each consisting of two affected nectarine and one peach tree. On 11 December a zinc spray was applied to four peach and two nectarine trees. Similarly affected trees were marked as checks. Spray mixtures were as follows:

(1) 3 lb. manganese sulphate + 4 lb. hydrated lime in 50 gal. water;

(2) 3 lb. ferric sulphate + 4 lb. hydrated lime in 50 gal. water;

(3) 3 lb. magnesium sulphate + 4 lb. hydrated lime in 50 gal. water;

(4) 3 lb. zinc sulphate + 4 lb. hydrated lime in 50 gal. water.

Observations made in January indicated that there had been a response to the zinc sprays. Zinc-treated trees appeared to be making more growth and there was a reduction in leaf chlorosis, although some symptoms were still visible. Check trees and trees receiving the other treatments showed no response. Towards the end of the season improvement in zinc-treated trees became less marked, but the effect was still apparent in the following spring (observations made 6 November, 1951).

In the spring of 1951 all plots received two applications of the same sprays as in the previous year—on 14 November and 17 December. Towards the end of this season the effect of the zinc treatment was definite. No "little-leaf" symptoms were visible in zinc-treated trees and all were making adequate new growth. Some slight leaf chlorosis was still apparent but all trees receiving zinc were better than checks in this respect. Check trees still showed marked symptoms, and none of the treatments other than zinc had resulted in any improvement.

FIG. 1.—Peach leaves, var. Royal George. Healthy leaf on left. Other leaves showing chlorotic symptoms of zinc deficiency.

Photo: S. A. Rumsey.

FIG. 2.—Leader of nectarine tree, var. Hunt's Tawny, showing "little-leaf" and leaf rosetting symptoms of zinc deficiency.

Photo: S. A. Rumsey.

FIG. 3.—Leaders of peach tree, var. Muir. One leader showing die-back, another showing "little-leaf" and rosetting, and a third leaf chlorosis only.

Photo: S. A. Rumsey.

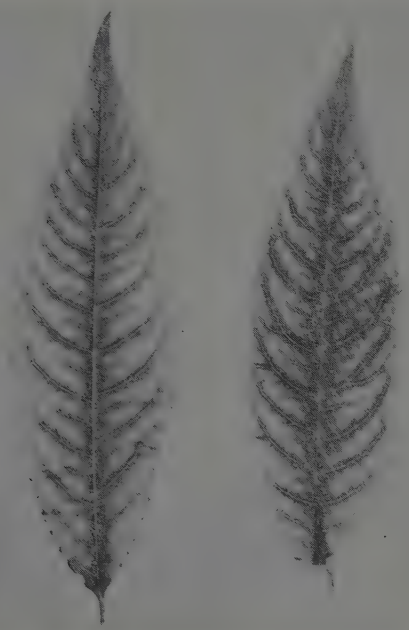

FIG. 4.—Peach leaf chlorosis caused by manganese and zinc deficiencies.
Left: Var. Paragon, manganese deficiency.
Right: Var. Royal George, zinc deficiency. *Photo: S. A. Rumsey.*

LEAF ANALYSIS

Zinc contents of leaves from deficient and apparently healthy trees were determined. Samplings were made from untreated trees in the experimental area, from apparently healthy trees in the Alexandra district and from apparently healthy trees in the Auckland district. Leaves for analysis were selected in each instance from the lower part of current season's growth. Zinc determinations were made by Miss T. Marwick, Soil Bureau, Department of Scientific and Industrial Research. The results were as follows:

Fruit	Source of material	Date of sampling	Zinc content (p.p.m. Zn in dry wt.)
Nectarine, var. Goldmine	Deficient tree, Clyde	25/2/52	7.5
	Healthy tree, Alexandra	25/2/52	11.0
	Healthy tree, Auckland	28/2/52	10.0
Peach, var. Royal George	Deficient tree, Clyde	25/2/52	5.6
	Healthy tree, Alexandra	25/2/52	15.0

While zinc levels in deficient trees are lower than in the apparently healthy trees, the differences are not marked. Chandler, Hoagland and Hibbard (1934) reported zinc levels of 6–15 p.p.m. in deficient peach leaves and 6–43 p.p.m. in healthy leaves. If these figures are accepted, it might indicate that even the "healthy" trees sampled above are tending to be low in zinc.

Control

The present work has shown that foliage sprays can largely rectify zinc deficiency in peaches and nectarines, even in a severe form. It has not been possible to test zinc sprays applied in other seasons or at other strengths.

Incidence

In New Zealand zinc deficiency in stone fruits has not been reported outside Central Otago. Severe symptoms of "little-leaf" and die-back have not been observed in peaches or nectarines on any orchard other than that referred to in this paper, but in the same district many blocks of peach and nectarine trees show intervenal foliar chlorosis. It is possible that some of these may be attributed to zinc and/or manganese deficiencies.

Acknowledgments

The writer wishes to acknowledge the co-operation of Mr. E. O'Reilly, Clyde, who permitted use of his trees. Thanks are due to Mr. W. S. Kemp, Horticulture Division, Department of Agriculture, for assistance with recording, and to Miss T. Marwick, Soil Bureau, Department of Scientific and Industrial Research, for carrying out the analyses.

References

Bollard, E. G., 1953: *N.Z. J. Sci. Tech. A34*: 548-50.

Chandler, W. H.; Hoagland, D. R.; Hibbard, P. L., 1934: *Proc. Amer. Soc. Hort. Sci. 30*: 70.

NOTE ON MANGANESE DEFICIENCY IN APPLE, PLUM AND QUINCE

By J. D. Atkinson and E. G. Bollard, Fruit Research Station, Department of Scientific and Industrial Research, Auckland

(*Received for publication, 19 March 1953*)

Introduction

Although not a major problem in New Zealand, manganese deficiency has been reported in grapefruit (Taylor and Burns, 1938), peaches (Atkinson, 1944), and apricots (Bollard, 1953). On mixed orchards where peaches are affected by manganese deficiency similar symptoms have occasionally been found in apple, plum, and quince. It seemed probable that shortage of manganese was affecting these fruits also, and to test the point trials detailed in this note were undertaken.

Symptoms

Apple, var. Dougherty

A form of leaf chlorosis is the only symptom that has been found on affected trees in this country. Chlorosis is not usually seen until fruit is about half grown, and may become more pronounced as the season progresses. Affected leaves may show either a pale chlorotic band round the margin, or a more extensive light yellow area involving both the leaf edge and the areas between the veins (Fig. 1). In a few leaves only the veins remain green. Under New Zealand conditions only a small proportion of leaves on an affected tree show chlorosis, and the tree continues to make both leader and lateral growth.

Plum, var. Doris

Symptoms on plum are similar to those on apple (Fig. 2). Affected plum trees also show only a small percentage of chlorotic leaves and no marked reduction in growth.

Quince, var. unknown

Trees suffering from manganese deficiency show intervenal leaf chlorosis as the most common symptom (Fig. 3). Some leaves become almost completely yellow, only a narrow strip of green remaining along main veins. First formed leaves are most seriously affected, but some near shoot tips also show symptoms. Over three quarters of the leaves on an affected tree may show chlorosis.

Incidence

In New Zealand manganese deficiency in apples has been found in the Auckland, Hastings and Central Otago areas. Plums affected by this disorder have been found both in the Hastings and Central Otago districts. Affected quinces have been found in Auckland and Hawke's Bay.

Manganese Treatments

All trees used in these trials were growing in fertile silt loams near Hastings, pH 6.3 7.2. Only a small number showing deficiency symptoms were available so that trial plots were of necessity small.

Apples and Plums

On 20 November five Dougherty apple trees in full bearing, and two large Doris plum trees were sprayed with the following mixture: Manganese sulphate, 5 lb. + hydrated lime, 4 lb., in 100 gal. of water. This mixture left a black unsightly deposit on leaves and young fruit. At their respective harvesting dates black residues had disappeared from the apples but not from the plums.

Four months after this single spray treatment, chlorosis had almost disappeared from both apple and plum leaves, and treated trees were a darker green than untreated check trees. Intervenal chlorosis had become more pronounced on the checks than it was in November. A year later effects of spray treatment were no longer visible and slight chlorosis was showing on both treated and check trees.

Quinces

On 5 February each of the three following spray treatments was applied to four trees:

1. Manganese sulphate, 3 lb. + hydrated lime, 4 lb., in 50 gal. water;
2. Ferric sulphate, 3 lb. + hydrated lime, 4 lb., in 50 gal. water;
3. Manganese sulphate, 1½ lb. + ferric sulphate, 1½ lb. + hydrated lime, 4 lb., in 50 gal. water.

Within a month of treatment striking improvement was visible in trees that had received Treatments 1 and 3. Chlorosis had largely disappeared and the leaves were a healthy dark green. Treatment 1 gave better results than 3. These differences were maintained until leaf fall, but were much less marked in the following summer.

Control

These small scale trials have shown that manganese sprays will correct a deficiency of this element in apple, plum, and quince trees. If a spray containing manganese sulphate and hydrated lime is applied soon after fruit set, black residues will not cause disfigurement of fruit at harvest. Limited trials have indicated that manganese sulphate alone may be applied safely as a spray to peaches, but information is not available on the reaction of apples, plums and quinces.

Many workers in various parts of the world have reported that manganese deficient plants do not respond to soil applications of this element. Healy (1953) has recently demonstrated that deficient peach trees in the Hastings area did not respond to soil dressings, but recovered rapidly when sprayed with manganese. Liquid or solid injection of manganese salts directly into an affected tree will eliminate deficiency symptoms, but the method is not suitable for routine use.

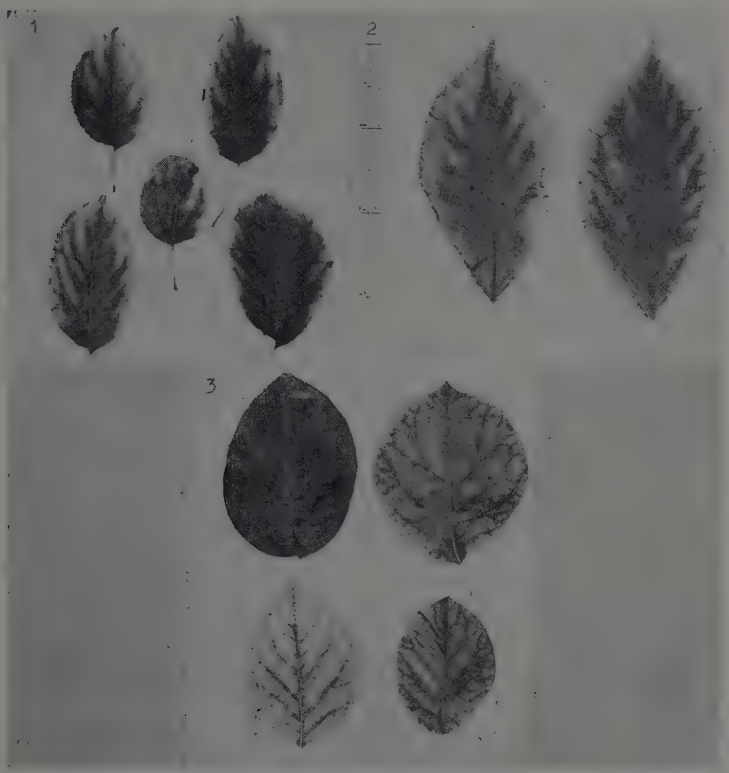

Fig. 1.—Dougherty apple leaves showing chlorosis caused by manganese deficiency.
Photo: L. H. Wright.

Fig. 2.—Doris plum leaves affected by manganese deficiency.
Photo: L. H. Wright.

Fig. 3.—Quince leaves showing symptoms of manganese deficiency.
Photo: S. A. Rumsey.

Where this disorder occurs an annual spray made to the following formula will give effective control:

Manganese sulphate, 5 lb. + hydrated lime, 4 lb. in 100 gal. water.

Acknowledgments

The authors are indebted to Mr. T. Conway and other officers of the Horticulture Division, Department of Agriculture, who assisted with field trials.

References

Atkinson, J. D., 1944: *Orchardist of N.Z., 17* (*11*): 8.
Bollard, E. G., 1953: *N.Z. J. Sci. Tech., A34*: 471-2.
Healy, W. B., 1953: *Ibid. A34*: 386-96.
Taylor, G. G.; Burns, M. M., 1938: *Ibid. 20*: 115A-9A.

MOVEMENT OF HEAVY APPLICATIONS OF BORAX THROUGH SOIL

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(*Received for publication, 5 March 1953*)

Summary

Applications of 1,200, 600 and 300 lb./ac. of borax were made to a fine sandy loam. After two weeks an amount greater than 300 lb./ac. was not accounted for in the top 24 in. of the soil treated at the 1,200 lb. rate, but at the same period 75 per cent of the original application was recoverable from the soil treated at the 300 lb. rate. After a year an average of 85 per cent of the original applications was unaccounted for, the rate of movement thus being approximately of the same order recorded by other workers for smaller rates of application.

Slight variations in soil reaction, with a tendency for the pH value to increase with time and, to a certain extent, with depth, appear to be connected with the applications of borax. The maximum variation in all pH values determined was 0.9 units, but the average pH values of the 0–24-in. sections varied, during the experiment, by only 0.5 units.

Increased boron contents at various distances up to 24 in. from the edge of a treated plot indicate lateral movement of applied borax. This increase is as much as 33 per cent of the boron content of the untreated soil in the top 24 in. at a distance of two feet from the treated area. The greatest increases are in the surface 6 in. suggesting that boron has been carried upwards, presumably by a rising water-table.

Introduction

Several workers have studied the movement of added boron through soil mainly using quantities of the order of normal fertilizer requirements. Krugel *et al.*[1] reported that boron was easily leached from the soil and that there was no reason to fear that it would accumulate there. They found that about one year's rainfall would leach out from loamy sands a dressing of 20 Kg./Hectare of borax. Askew *et al.*[2] noted that applications, in the field in the Nelson district, of 50 and 100 lb./ac. of borax had penetrated into the soil to a depth of at least 18 in. after a period of 5 months, and to a depth of at least 30 in. during a year. They noted also that the boron content of the soil in the main root area, after 3 years was maintained at a level at least twice as high as that in the control areas. Reeve *et al.*[3] found that 85 per cent of an application of 20 lb./ac. of borax was removed from the 7-in. depth by the equivalent of 11 in. of rain. Kubota *et al.*[4] showed that an application of 40 lb./ac. of borax had passed beyond the 36-in. level in six months and that an application of 100 lb./ac. of borax to a fine sandy loam had, with the addition of 1.2 in. of water, been distributed as follows:

0–6 in., 16 per cent; 6–9 in., 23 per cent; 9–12 in., 25 per cent; 12–15 in., 2 per cent.

They observed that most of the movement was "in mass rather than portions at a time." Winsor[5] reported the distribution of boron after three weeks and 9.95 in. of rain as being:

0–6 in. 9 per cent; 6–18 in. 59 per cent; 18–30 in. 32 per cent.

The rate of application is not given. Brown *et al.*[6] showed that, on the average, 50 per cent of the borax applied at a rate of 20 lb./ac.

was recovered in the 0–8-in. level after 18 months. After 7 years there was still a 20 per cent increase in the boron content of the 0–6-in. level and about a 25 per cent increase in the 8–10-in. level. Wilson *et al.*[7] found that an application of 40 lb. ac. of borax to a fine sandy loam was almost completely lost from the surface 8 in. within 6 months and that after application of 30 lb. ac. of borax annually for six years most of the water-soluble boron was in the 12–30-in. level at a concentration of 0.8–1.1 p.p.m.

Because little is known of the movement of larger applications of borax it was considered of interest to examine the movement, both vertically and laterally, of rates such as might be used for purposes other than the control of boron-deficiency ailments.

EXPERIMENTAL PROCEDURE

Field plots were established on a Riwaka fine sandy loam, a recent soil derived from basic igneous rocks, limestone, granite and Moutere gravels. The top soil is a dark grey fine sandy loam 18 in. deep. From 18 to 42 in. depth it is a light brown fine sandy loam.

Three rates of borax were applied as follows:

300 lb./ac., two replications; 600 lb./ac., two replications; 1,200 lb./ac., one plot.

Weed growth on the plots was cut back to ground level at the time of application and at intervals during the period of the experiment. These plots were used to study the vertical penetration of boron. A further plot, treated with borax at the rate of 600 lb./ac. and completely freed of vegetation prior to the application, was used in a study of the lateral movement of boron.

The plot size was 12 × 24 ft in the penetration experiment and 6 × 12 ft in the lateral movement experiment. No other treatment was given the plots. Beginning two weeks after borax was applied, the soil from the penetration plots was sampled at intervals during the year. Sampling was by 2-in. sections, by means of a tubular auger, down to 24 in. Cores from the replicate plots were combined into one sample. In the case of the lateral movement experiment only one sampling was done, after a year, the samples being taken in 3-in. sections to a depth of 24 in. and at distances of 6, 12, 18 and 24 in. from the edge of the treated plot. From each of the replicate plots in the penetration experiment, five cores were taken at random at each sampling, and from the single plot treated at the rate of 1,200 lb./ac. of borax eight cores were taken at each sampling. Holes were carefully filled in, after each sampling, with soil from outside the plots and pegged to avoid them being resampled on subsequent dates. In the lateral experiment, eight cores were taken at each distance sampled from the edge of the treated plot. Prior to setting out the plots a soil sample consisting of ten cores was taken at random over the area.

The pH values for the complete series of soil samples were determined. All soil samples were analysed for water-soluble ("available") boron by Berger and Truog's method[8], the boron in solution being estimated by the method of Maunsell[9], with the modification suggested by Berger and Truog[8] that the quinalizarin be added to the stock acid solution.

Calculations made from the analytical figures obtained are based on the assumption that an acre of soil to a depth of 8 in. is equivalent to two million pounds of soil.

TABLE 1. BORON CONTENT (p.p.m. B), AT VARIOUS PERIODS, OF SOIL TREATED WITH DIFFERENT AMOUNTS OF BORAX

Sample depth (in.)	Sampling Dates* 16-8-50 (2 wks.)	14-9-50 (6 wks.)	19-10-50 (2½ mths.)	5-12-50** (4 mths.)	23-4-51 (9 mths.)	6-8-51 (12 mths.)
	Application of 1,200 lb./ac. of Borax					
0- 6	24.7	14.6	10.7	8.9	4.6	5.1
6-12	18.1	19.1	13.2	10.0	4.8	6.5
12-18	13.4	16.1	13.2	11.3	5.1	6.1
18-24	6.9	10.6	11.0	10.0	4.7	4.4
Average (0-24)	15.8	15.1	12.0	10.1	4.8	5.5
	Application of 600 lb./ac. of Borax					
0- 6	13.1	3.9	5.4	4.4	3.3	1.2
6-12	11.2	9.0	6.3	8.5	3.1	1.4
12-18	10.2	6.3	6.2	8.1	3.9	1.6
18-24	6.1	2.3	3.4	5.1	2.8	1.4
Average (0-24)	10.2	5.4	5.3	6.5	3.3	1.4
	Application of 300 lb./ac. of Borax					
0- 6	8.0	2.7	4.4	3.8	1.8	1.4
6-12	5.6	3.8	5.2	5.0	2.5	1.4
12-18	3.0	2.3	4.5	3.6	2.4	1.2
18-24	2.0	1.3	2.5	2.0	1.7	0.9
Average (0-24)	4.7	2.5	4.2	3.6	2.1	1.2

*Prior to application of borax the boron contents of corresponding sections were: 0–6 in., 0.38; 6–12 in., 0.46; 12–18 in., 0.48; 18–24 in., 0.45.

**At this date additional depths were sampled, the following boron contents obtained on analysis:

1,200 lb. rate: 24–30 in., 6.2; 30–36 in., 3.4; 36–42 in., 1.9.
600 lb. rate: 24–30 in., 3.9; 30–36 in., 2.9; 36–42 in., 1.1.
300 lb. rate: 24–30 in., 1.5; 30–36 in., 0.87; 36–42 in., 0.65.

TABLE 2. pH VALUES, AT VARIOUS PERIODS, OF SOIL TREATED WITH DIFFERENT AMOUNTS OF BORAX

Sample depth (in.)	Sampling Dates* 16-8-50 (2 wks.)	14-9-50 (6 wks.)	19-10-50 (2½ mths.)	5-12-50** (4 mths.)	23-4-51 (9 mths.)	6-8-51 (12 mths.)
	Application of 1,200 lb./ac. of Borax					
0- 6	5.0	5.2	5.5	5.6	5.4	5.6
6-12	5.0	5.1	5.4	5.4	5.4	5.45
12-18	5.2	5.1	5.6	5.3	5.5	5.6
18-24	5.3	5.4	5.6	5.6	5.7	5.7
Average (0.24)	5.1	5.2	5.5	5.5	5.5	5.6
	Application of 600 lb./ac. of Borax					
0- 6	5.5	5.55	5.2	5.5	5.2	5.4
6-12	5.3	5.4	5.2	5.3	5.3	5.3
12-18	5.4	5.5	5.2	5.5	5.5	5.3
18-24	5.5	5.6	5.4	5.6	5.65	5.7
Average (0-24)	5.4	5.5	5.25	5.5	5.4	5.4
	Application of 300 lb./ac. of Borax					
0- 6	5.5	5.5	4.9	5.3	5.4	5.5
6-12	5.3	5.3	5.1	5.4	5.5	5.55
12-18	5.5	5.5	5.3	5.6	5.7	5.7
18-24	5.7	5.7	5.45	5.8	5.8	5.8
Average (0-24)	5.5	5.5	5.4	5.5	5.6	5.6

*Prior to the application of borax the pH values of corresponding sections were: 0–6 in., 4.9; 6–12 in., 5.05; 12–18 in., 5.1; 18–24 in., 5.3.

**At this date additional depths were sampled, the following pH values being obtained:

1,200 lb. rate: 24–30 in., 5.75; 30–36 in., 5.75; 36–42 in., 5.8.
600 lb. rate: 24–30 in., 5.65; 30–36 in., 5.7; 36–42 in., 5.75.
300 lb. rate: 24–30 in., 5.85; 30–36 in., 5.9; 36–42 in., 5.75.

RESULTS

A. Penetration Experiment

The results for water-soluble boron in soil samples taken on six occasions and at four depths are shown in Table 1. (Samples were

taken by 2-in. sections but are presented here as from 6-in. sections, the figures given being the mean value of each group of three 2-in. cores). The corresponding pH values for these soils are shown in Table 2.

Distribution of Water-soluble Boron 2 Weeks After Application of Borax

The initial movement to depths of 24 in. or more, during two weeks after 4.2 in. rainfall, has been rapid. For each of the three rates of application, the highest concentrations are in the uppermost levels, the concentration progressively decreasing to the lowest level sampled. Of the 1,200-lb. application 32 per cent has not been accounted for. However, the water-soluble boron content of the 22–24-in. section was 6.0 p.p.m. Doubtless much of the boron not accounted for has passed beyond the 24-in. depth. This apparent loss is greater than the total application to the 300-lb. plot but in this latter area 76 per cent of the application is still within the section of soil sampled. The 600-lb. application did not move so rapidly as the other two, and only 15 per cent had penetrated past 24 in. or become unavailable in other ways.

There has, in general, been an increase in pH value at all depths, negligible for the 1,200-lb. rate and progressively higher for the other two rates. The pH value tends to increase with depth of sampling, as does the untreated soil.

Distribution of Water-soluble Boron 6 Weeks After Application of Borax

There has been, following a further 3.1 in. of rain, a greater loss from the surface levels of each plot than for the other levels. In the case of the 1,200-lb. rate there is a slight build-up in the lower levels, especially in the two lowest sections, probably due to a transfer from the uppermost section. The greatest concentration of boron was at a depth between 6 in. and 14 in. There has been only another 4 per cent beyond the 32 per cent lost after two weeks, of the original application unaccounted for in this plot. For the 600-lb. rate, 56 per cent of the boron applied has not been found by analysis, the loss being greater than the total application to the 300-lb. plot, though the latter still retains 37 per cent of the applied boron in a form determinable by the method of analysis employed. For the two lower rates of application the highest concentration of boron was at about 8 in. below the surface of the soil, but with the heaviest application the boron content was about 19 p.p.m. over the 6–14-in. depth. There have been no increases in boron content in any of the levels of the two lower rates of application.

There has been a further slight increase in pH value for all depths except for the 300-lb. rate. In this case the pH values at all depths remain the same as for the previous sampling. The tendency for the pH value to increase with depth is still apparent for the lower sections, but in all rates the uppermost 6 in. has a higher pH than the next lowest section. It is in the top 6 in. that the greatest loss in boron content occurred.

Distribution of Water-soluble Boron 2½ Months After Application of Borax

In the 1,200-lb. plot there has been further loss of boron with the different levels tending to become equal in boron content at a concentration of about 13 p.p.m. There has been a slight increase in the 18–24-in. depth. There is now 51 per cent of the original application not accounted for as water-soluble boron. This is equal to the total application to the 600-lb. plot and equal to twice the application to the 300-lb. plot though these two plots still have available 44 per cent and 66 per cent respectively of their original applications. The 600-lb. rate shows a slight loss and has tended to redistribute the boron content, the surface and lowest levels being increased at the expense of the 6–12-in. level. Down to a depth of 18 inches the water-soluble boron content varies only from 5.3 to 7.0 p.p.m. In the 300-lb. rate the boron content at all levels has been considerably increased, the available boron now being 66 per cent of the original application as compared with 37 per cent at the previous sampling. The maximum concentration of boron (5.5 p.p.m.) is at 8–12 in. below the surface.

While the pH values at all levels in the 1,200-lb. rate show a further marked increase, those of the 600- and 300-lb. rates show pH values lower at all levels than after two weeks. The total rainfall to this date was 10.2 in.

Distribution of Water-soluble Boron 4 Months After Application of Borax

There has been a further slight reduction of available boron content in the 1,200-lb. plot at all levels and the concentration over the range in depth from 6 to 24 in. is relatively constant at about 10 p.p.m. Appreciable amounts of boron are shown to be present down to a depth of at least 42 in., about 1.5 per cent of the added borax being recovered from the 36–42-in. section. In the 600-lb. plot there has been a slight reduction in the surface level, but a build-up in the lower levels. A maximum concentration of nearly 10 p.p.m. is found at depths between 8 and 14 in. With the 300-lb. rate only minor decreases at all levels are shown. There is now 57 per cent unaccounted for in the highest rate while 58 per cent of the original application still remains in the top 24 in. at the lowest rate. The relatively small changes in boron concentration, on all plots, between this and the previous samplings are probably due to the dry weather experienced in this interval, the rainfall being only 0.54 in.

There has been an increase in pH values at all levels except in the 6-18-in. level of the 1,200-lb. plot. All three rates of application now have the same average pH value and, again, the value tends to increase with depth except in the uppermost 6 in.

Distribution of Water-soluble Boron 9 Months After Application of Borax

In this period the boron content at all rates of application fell to about half those recorded after 4 months. Rainfall between the two sampling dates reached a total of 30.5 in., thus materially increasing the opportunities for leaching to occur. The 1,200-lb. rate has

now levelled out, the concentration of boron in each section being approximately 5 p.p.m. Only 26 per cent of the original application has been accounted for. For the 600-lb. rate the maximum boron content is at the 12–18-in. level while for the 300-lb. rate the maximum was 2.7 p.p.m. over the range 8 to 14 in., the average for the whole depth sampled being 2.1 p.p.m. In this latter plot there is still 30 per cent of the original application present in water-soluble form.

The pH values decreased in the surface level of the 1,200-lb. plot but increased in the two lowest levels. The 600-lb. plot showed a decrease in pH value in the surface level but remained unchanged at other levels. For the 300-lb. rate increases occur in the pH value of the soil at all levels. At this sampling the pH value of the uppermost 6 in. is now not greater than that of the next lowest section.

Distribution of Water-soluble Boron 12 Months After Application of Borax

In the 1,200-lb. plot there are slight increases in boron content at all levels except the lowest, making, at the conclusion of the experiment, 22 per cent of the original application still recoverable by the analytical methods used. The average water-soluble boron content in the top 24 in. is 5.5 p.p.m. The 600-lb. plot has lost further boron at all levels and has now an average boron content of only 1.4 p.p.m. It contains only 9 per cent of its original application of borax. Further loss of boron has occurred in all levels of the 300-lb. plot, greater in the lower levels than in the surface. This plot at the end of a year still retained 13 per cent of its original application of borax in the top 24 in., the average boron content being 1.2 p.p.m.

There are still further slight increases in pH values of the soil in most of the levels of all rates of application of borax. The total rainfall for the period of the experiment was 59.5 in.

TABLE 3. BORON CONTENT (p.p.m. B) OF SOIL AT VARIOUS DISTANCES FROM THE EDGE OF A PLOT TREATED A YEAR BEFORE SAMPLING WITH BORAX AT THE RATE OF 600 lb./ac.

Sample depth (in.)	Distance from edge of Treated plot					Untreated *
	6 in. Inside	6 in. Outside	12 in. Outside	18 in. Outside	24 in. Outside	
0- 6	2.4	0.87	0.68	0.68	0.59	0.32
6-12	1.9	0.70	0.60	0.62	0.55	0.42
12-18	1.7	0.89	0.77	0.84	0.66	0.46
18-24	0.9	0.73	0.64	0.59	0.45	0.50
Average (0.24)	1.7	0.80	0.67	0.68	0.56	0.43

*Untreated soil prior to applications of borax, a year before samples were taken.

TABLE 4. pH VALUES OF SOILS AT VARIOUS DISTANCES FROM THE EDGE OF A PLOT TREATED A YEAR BEFORE SAMPLING WITH BORAX AT THE RATE OF 600 lb./ac.

Sample depth (in.)	Distance from edge of Treated plot					Untreated *
	6 in. Inside	6 in. Outside	12 in. Outside	18 in. Outside	24 in. Outside	
0- 6	5.6	5.3	5.4	5.2	5.2	5.3
6-12	5.45	5.3	5.1	5.2	5.2	5.1
12-18	5.4	5.4	5.2	5.2	5.4	5.45
18-24	5.4	5.45	5.4	5.4	5.5	5.5
Average (0.24)	5.5	5.4	5.3	5.3	5.3	5.3

*Untreated soil prior to application of borax, a year before samples were taken.

B. Lateral Movement Experiment

The results for water-soluble boron in soil samples taken one year after initiation of the lateral movement experiment are shown in Table 3 and the corresponding pH values are shown in Table 4. (Samples were taken by 3-in. sections but are recorded here as from 6-in. depths, the boron content of each pair of 3-in. cores being averaged).

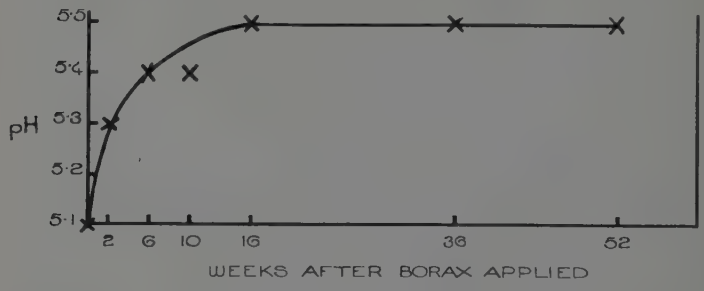
At all sampling distances outside the treated plot the greatest concentration of boron is in the 12–18-in. level. The boron content ranges from 0.89 p.p.m. at a distance of 6 in. to 0.66 p.p.m. at a distance of 24 in. from the edge of the plot, i.e., the boron content has increased by 93.5 per cent and 43.5 per cent of its initial value in this level. The percentage increase in boron content over the initial values is, at all distances, greatest in the surface 6 in., ranging from 172 per cent at 6 in. distance to 84 per cent increase at a distance of 24 in. The average percentage increase in boron content of the 0–24-in. section at the furthest distance sampled was 30 per cent.

In this plot there were no significant changes in pH values at the further distances sampled as compared with the untreated soil but at distances of 6 in. inside and 6 in. outside the edge of the treated plot slight increases occur in the pH value.

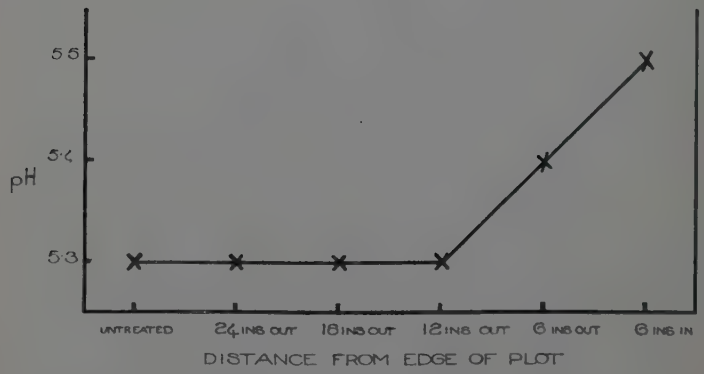
DISCUSSION

The movement of added boron in this fine sandy loam has been rapid. It is known that when boron is applied to soil as borax a part of it remains in the soil solution and a part is removed from solution in forms that are not very soluble, while an equilibrium tends to be maintained between these two phases. Thus, although on the 1,200-lb. plot an amount of boron greater that the total application to the 300-lb. plot was unaccounted for after two weeks, this latter plot has 75 per cent of its original application still available. Figures given by Berger and Truog[10] also show that

the loss from a higher rate may be greater than the total applications at lower rates though the latter will still show an increase in boron content throughout the soil. With increasing time, the quantities unaccounted for tend to approach one another, and after a year 78 per cent, 91 per cent and 87 per cent of applied borax had become unaccounted for in the top 24 in. of the 1,200, 600 and 300-lb. plots respectively. These percentages are of the same order found by other workers with smaller rates of application. However, the water-soluble boron still recoverable from the top 24 in. of the soil after a year are, for the three rates of application, 5.5, 1.4 and 1.2 p.p.m. The concentrations of boron recovered from the lowest depths sampled after a fortnight (6.9 p.p.m. in the 1,200 lb. plot) suggest that a considerable proportion of the added



(A) PENETRATION EXPERIMENT



(B) LATERAL EXPERIMENT

FIG. 1.—pH values: (A) at different times in the penetration experiment; and (B) at different distances in the lateral movement experiment.

boron not recovered at this date had penetrated beyond the 24-in. level during this time. No precise determination was made of the fixation properties of the soil but it is indicated that this is not very great.

At most sampling periods for the penetration experiment there have been slight variations in soil reaction as expressed by the pH values. At different levels during any one period the pH value tends to increase with depth as it does in the untreated soil. There is also a tendency for the reaction to increase at the different sampling dates particularly in the first four months. The average pH values of the three rates of application at the different sampling dates are shown in Fig. 1 (A). After two weeks no change had occurred in the pH of the 0–24-in. section of the 1,200-lb. plot. The 600-lb. plot had increased in soil reaction by 0.3 pH units and the 300-lb. plot by 0.4 pH units. The maximum variation in all pH values determined was 0.9 units, from 4.9 to 5.8. The variation for the 0–24-in. depth was from 5.1 to 5.6, i.e., 0.5 pH units. It is recognised that considerably greater variations in soil reaction can occur over a period due to a number of causes and that the slight changes recorded here could be credited to these. However, since in the lateral movement experiment (see Fig. 1 (B)) such variations have not occurred at the furthermost distances sampled, but do occur within and immediately adjacent to the treated plot, it is felt that the increases found are connected with the application of borax to the soil. Unfortunately no soil samples were taken from untreated soil other than prior to making the applications so this belief cannot be substantiated. Laboratory tests in which borax solutions, of concentrations of the order occurring in this experiment, were shaken with soil and left overnight gave no significant changes in pH value of the suspension as compared with a water : soil suspension. At the first sampling period the 300-lb. plot had a higher pH value than the 600-lb. plot and both these plots were more alkaline in soil reaction than the 1,200-lb. plot. A similar effect in which higher reactions are associated with lower concentrations of boron was noted by Eaton and Wilcox[11] with Duocil, an artificial sodium aluminium silicate which behaved somewhat like soil.

With any application of borax an amount of sodium slightly greater than that of boron (expressed as parts per million of the element) is added to the soil and it is possible that this added sodium could exert some influence on the soil. Lehr[12] concluded from studies using sodium and calcium nitrates that the application of sodium exercises a small but mainly significant effect on the pH value. He also showed that a sandy soil of high buffer capacity did not respond initially to sodium but as time went on the effects become more marked. Kubota *et al.*[4] have indicated that the movement of sodium, added to the soil as borax, lags behind that of the boron and that, due to partial fixation, the movement of boron lags behind that of the water. Several workers have found a general positive relationship between exchangeable sodium content of the soils and the soil reaction.

In the lateral movement experiment, an increase of 33 per cent of the original soil boron content has occurred 24 in. from the edge of

the treated plot. The most remarkable effect is that the surface level, at all distances sampled, has shown the greatest percentage increase in boron content. This is thought to be due to the water-table rising close to the surface at one period during the year, the boron being deposited there as the waters receded or evaporated. The fact that the soil samples from the lateral movement plot have a slightly higher average boron content than the corresponding 600-lb. plot in the penetration experiment (17 p.p.m. as compared with 14 p.p.m.) may be due to boron not utilised by any weed growth as occurred on the penetration plots. The boron content of the surface 6 in. of the lateral plot is double that of the corresponding section of the penetration plot.

In general, these experiments show that the rate of movement of heavy applications of borax through a sandy loam corresponds to those of lighter applications but even after a year the residual concentrations of water-soluble boron are still of an order which might prove toxic to many plants, especially young seedlings. Some lateral movement does occur, the concentration of boron being more than doubled at a distance of 18 in. from a treated area. This increase could be significant in certain experimental work and suggests the desirability of the use of "guard rows."

Acknowledgements

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References

1. Krugel, C.; Dreyspring, C.; Lotthamer, R., 1938: Leaching Tests with Borates. *Superphosphate 11*: 141-50; 161-6.
2. Askew, H. O.; Thomson, R. H. K.; Chittenden, E., 1938: Effect of Borax Top-dressing on Boron Status of Soils and Fruits. *N.Z. J. Sci. Tech. 20*: 74A–8A.
3. Reeve, E.; Prince, A. L.; Bear, F. G., 1944: The Boron Needs of New Jersey Soils. *N.J. Agric. Exp. Sta. Bull. 709.*
4. Kubota, J.; Berger, K. C.; Truog, E., 1948: Boron Movement in Soils. *Proc. Soil Sci. Soc. Amer. 13*: 130-4.
5. Winsor, H. W., 1951: Boron Retention in Rex Fine Sand as Related to Particle Size of Colemanite Supplements. *Soil Sci. 71*: 99-104.
6. Brown, B. A.; Munsell, R. I.; King, A. V., 1945: Potassium and Boron Fertilization of Alfalfa on a Few Connecticut Soils. *Proc. Soil Sci. Soc. Amer. 10*: 134-40.
7. Wilson, C. M.; Lovvorn, R. L.; Woodhouse, W. W. Jr., 1951: Movement and Accumulation of Water-soluble Boron within the Soil Profile. *Agron. J. 43*: 363-7.
8. Berger, K. C.; Truog, E., 1944: Boron Tests and Determinations for Soils and Plants. *Soil Sci. 57*: 25-36.
9. Maucnsell, P. W., 1940: The Estimation of Boron by Means of Quinalizarin. *N.Z. J. Sci. Tech. 22*: 100 B–11B.
10. Berger, K. C.; Truog, E., 1945: Boron Availability in Relation to Soil Reaction and Organic Matter Content. *Proc. Soil Sci. Soc. Amer. 10*: 113-6.
11. Eaton, F. M.; Wilcox, L. V., 1939: The Behaviour of Boron in Soils. *U.S. Dep. Agric. Tech. Bull. 694.*
12. Lehr, J. J., 1952: Importance of Sodium for Plant Nutrition. V. Response of Crops other than Beet. *Soil Sci. 72*: 157-66.

SEED DISINFECTION

VII. EFFECT OF SEED TREATMENTS ON EMERGENCE OF LINSEED AND LINEN FLAX

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Summary

Eleven fungicidal treatments were used in preliminary glasshouse tests to determine the effect of seed treatment on emergence of linseed and linen-flax. Five of these, viz. Cuprox, Panogen, ferbam, Thirodust and Phygon, were used in further emergence tests of three linseed and three linen flax varieties in both glasshouse and field.

Differences in the effects of treatments were similar for all varieties.

Organo-mercury compounds depressed emergence in glasshouse tests. This result was confirmed in field tests for the one mercury compound (Panogen) used.

Thirodust and Phygon, although depressing emergence in glasshouse tests, significantly increased emergence in field trials.

Cuprox, in general, increased emergence but was not as effective as Thirodust and Phygon.

Ferbam had little effect on emergence.

INTRODUCTION

Organo-mercury compounds and other organic fungicides have been tested in experiments to assess the value of seed treatment in reducing pre-emergence losses of linseed and linen-flax.

MATERIALS AND METHODS

Effect of seed protectants on emergence of seed was investigated in glasshouse and field trials. These were laid out in blocks within which treatments were randomized.

The following materials were used:

Cuprox (50 per cent copper oxychloride), a wettable powder;
Panogen (0.8 per cent methyl mercury dicyan diamide), a liquid;
Panogen Special (0.4 per cent methyl mercury dicyan diamide), a liquid;
thiram (98 per cent tetramethyl thiuram disulphide), a powder;
Thirodust (75 per cent micronized thiram), a dust;
Fernasan (50 per cent thiram), a dust;
Granosan N.1. (5 per cent ethyl mercury phosphate), a dust;
Granosan M (7.7 per cent ethyl mercury *p*-toluene sulphonamilide), a dust;
Tetroc (98 per cent tetra-chloro-parabenzoquinone), a dust;
Phygon (98 per cent 2, 3 dichloro, 1–4 naphthoquinone), a dust;
ferbam (98 per cent ferric dimethyl dithiocarbamate), a powder.

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An additional treatment was the use of hot water steep, viz. freely dusting seed with hydrated lime and then steeping it in one per cent hydrated lime in water held at 126° F. (Bayliss, 1942).

Varieties treated were as follows:

Linseed: Golden Viking, Sheyenne and Koto;
Linen flax: Liral Crown, Stakhanovetz and 803/3.
Materials were applied as percentages of seed weight (Jacks, 1951).

Glasshouse tests were carried out at Auckland in seed boxes (18 in. × 12 in. × 3 in.). Treatments were sown in triplicate with 50 seeds per replication. Temperature in the glasshouse was 65 ± 6° F. and soil moisture was maintained at 40 per cent water holding capacity.

Field trials were carried out at Lincoln in 1950 and 1951. Sowings were made at end of September and again at the end of November. Approximately 400 seed (by weight) were sown per eight-foot row, there being five replications per treatment. The depth of sowing was approximately one inch. Emergence counts were made when the plants were eight to twelve inches high.

Records* for rainfall and temperature were as follows:

Rainfall: October 1950, 4.28 in.; December 1950, 4.22 in. October 1951, 3.73 in.; December 1951, 3.66 in.

Mean soil temperature: October 1950, 52.1° F.; December 1950, 56.8° F.; October 1951, 51.6° F.; December 1951, 53.3° F.

* Supplied by Canterbury Agricultural College, Lincoln.

Results

A. Glasshouse Tests

Experiment 1: A screening test was carried out with Golden Viking seed treated with the following compounds, the rate of application in percentages seed weight being given in parenthesis:

Cuprox (1.0 and 2.0), Panogen (0.3 and 0.6), Panogen Special (0.3 and 0.6), thiram (1.0 and 2.0), Thirodust (1.0 and 2.0), Fernasan (1.0 and 2.0), Tetroc (1.0 and 2.0), Phygon (1.0 and 2.0), ferbam (1.0 and 2.0), Granosan M (1.0 and 2.0), Granosan N.I. (1.0 and 2.0), and hot water. Panogen Special (0.6), Tetroc (1.0 and 2.0), Phygon (1.0 and 2.0), hot water, Granosan M (1.0 and 2.0) and Granosan N.I. (1.0 and 2.0) significantly depressed emergence.
No treatment used significantly increased emergence.

Experiment 2: Seeds of the following varieties were used: Golden Viking, Stakhanovetz, 803/3, Sheyenne, Liral Crown and Koto. These were treated with: Cuprox (1.0), Panogen Special (0.3), ferbam (1.0), Thirodust (1.0) and Phygon (0.5 per cent).

Interaction between treatments and varieties was not significant. Panogen Special, Thirodust and Phygon significantly depressed emergence. Cuprox and ferbam brought about significantly higher emergence than Thirodust and Phygon, but none of the materials increased emergence over check.

TABLE 1

MEAN EMERGENCE IN FIELD TRIALS, 1950 (EXPERIMENT 4)

Variety	September Sowing						November Sowing					
	Treatment						Treatment					
	Cuprox	Panogen	Ferbam	Thirodust	Phygon	Check	Cuprox	Panogen	Ferbam	Thirodust	Phygon	Check
Golden Viking	308	253	229	336	260	248	143	73	67	171	143	110
Sheyenne	249	240	227	238	246	248	188	170	172	207	171	207
Koto	230	210	212	237	227	256	214	180	182	216	219	218
Liral Crown	308	277	281	289	279	258	198	225	224	247	252	190
Stakhanovetz	255	287	319	358	323	320	198	224	220	298	233	190
803/3	322	279	323	302	303	298	233	231	179	245	270	207
Means	279	258	265	293	273	271	194	184	174	231	215	186
Difference for significance.												
Within varieties	5%: 42; 1%: 54						5%: 53; 1%: 70					
Treatment means	5%: 17; 1%: 22						5%: 22; 1%: 28					

TABLE 2

MEAN EMERGENCE IN FIELD TRIALS, 1951 (EXPERIMENT 5)

Variety	September Sowing						November Sowing					
	Treatment						Treatment					
	Cuprox	Panogen	Ferbam	Thirodust	Phygon	Check	Cuprox	Panogen	Ferbam	Thirodust	Phygon	Check
Golden Viking	247	277	250	266	285	249	243	234	225	266	274	226
Sheyenne	360	230	320	324	364	332	349	329	357	358	345	338
Koto	357	316	342	327	327	317	339	340	327	341	351	315
Liral Crown	383	365	417	423	440	428	480	345	469	463	473	469
Stakhanovetz	474	299	459	463	504	441	504	333	473	508	519	527
803/3	421	0	381	419	404	342	441	347	357	401	391	365
Means	374	248	361	370	387	351	393	321	368	389	392	373
Difference for significance.												
Within varieties	5%: 48; 1%: 65						5%: 37; 1%: 50					
Treatment means	5%: 19; 1%: 26						5%: 15; 1%: 20					

Experiment 3: Seeds of Golden Viking, Sheyenne, Koto, Liral Crown, Stakhanovetz and 803/3 were treated with: Cuprox (1.0), Panogen (0.3), ferbam (1.0), Thirodust (1.0) and Phygon (0.5).

In general, Phygon, Thirodust and Panogen depressed emergence as compared with control. This effect, however, attained significance only in three instances, viz. Phygon significantly depressed emergence of Golden Viking, Thirodust that of Sheyenne, and Panogen that of Stakhanovetz. None of the seed dressings increased emergence over check.

B. Field Tests

Experiment 4: 1950 Trials: Varieties and treatments were as given in Experiment 3. Results are shown in Table 1.

October Sowing: Significant increase of emergence was brought about by Cuprox with Golden Viking and Liral Crown, and Thirodust with Golden Viking. Emergence was significantly depressed in the case of Cuprox with Stakhanovetz, and Panogen and ferbam, with Koto. Over all varieties Thirodust brought about significant increase in emergence, whilst other treatments did not vary significantly from the check.

November Sowing: Thirodust significantly increased emergence of Golden Viking, Liral Crown and Stakhanovetz, and Phygon, that of Liral Crown and Stakhanovetz. None of the treatments significantly depressed emergence. In general, Thirodust, and to a lesser extent Phygon, brought about significant increase in emergence over all varieties, whereas other treatments did not vary significantly from check.

Experiment 5: 1951 Trials: Varieties and treatments were as given in Experiment 3; results are shown in Table 2.

September Sowing: Significant increase of emergence was brought about by Cuprox, Thirodust and Phygon with the variety 803/3; Phygon also significantly increased emergence of Stakhanovetz. Panogen significantly depressed emergence of Sheyenne, Liral Crown, Stakhanovetz and 803/3. Over all varieties, Thirodust and Phygon significantly increased, whilst Panogen significantly depressed emergence. Other treatments did not vary significantly from check.

November Sowing: Cuprox and Thirodust significantly increased emergence of 803/3, Thirodust and Phygon that of Golden Viking. Panogen significantly depressed emergence of Liral Crown. Panogen and ferbam that of Stakhanovetz. Over all varieties, Cuprox, Thirodust and Phygon brought about significant increase in emergence. Panogen significantly depressed emergence, whereas other treatments did not vary from the check.

DISCUSSION

As mercury compounds, generally, gave a depressing effect on emergence in preliminary trials, further tests were carried out with one mercury fungicide and four other fungicides based on copper oxychloride, ferbam, thiram and dichloro-naphthoquinone to assess their effect on emergence of three linseed and three linen flax varieties.

Panogen, Thirodust and Phygon depressed emergence under glasshouse conditions. This result was confirmed for the material Panogen in field tests; Thirodust and Phygon, however, had beneficial effects on emergence under field conditions.

An analysis of variance combining results from all four field trials showed that differences between trials, varieties and treatments, and trials-versus-variety interaction were all highly significant, and that interactions of trial-versus-treatment and variety-versus-treatment were not significant. Differences in effects of treatments were similar for all varieties. Thirodust and Phygon were the most effective seed disinfectants tested, giving an increase in emergence of 8.4 per cent. and 6.4 per cent respectively. Panogen reduced emergence by 10.4 per cent, Cuprox increased and ferbam depressed emergence by 4.4 per cent and 1.7 per cent respectively, but neither figure attained significance.

Glasshouse tests did not give reliable information regarding efficacy of some seed dressings, viz. Thirodust and Phygon, which in the field proved effective. Toxic effects of mercury compounds as revealed by glasshouse tests were however confirmed in field trials.

From results of these tests it appears that application of materials based on thiram and dichloro-naphthoquinone to linseed and linen flax is preferable to that of organo-mercury compounds.

Acknowledgements

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References

Bayliss, G. T. S., 1942: *N.Z. J. Sci. Tech. A23*: 1-8.
Jacks, H., 1951: *Ibid. A33*: 27-38.

SEVERE POTASH DEFICIENCY IN YOUNG PEACH TREES

By E. G. Bollard, Fruit Research Station, Department of Scientific and Industrial Research, Auckland

(*Received for publication, 19 March 1953*)

Summary

Potash deficiency was found to cause poor growth and severe marginal necrosis of the leaves of young peach trees in the Auckland district. Dressings of 5 cwt of potash per acre were required to rectify the disorder. Tissue tests showed differences in potassium status of affected and healthy trees.

Introduction

Although potash manures are often included in fertiliser programmes for most types of fruits in New Zealand, instances of potash deficiency symptoms are rare even on unmanured properties. This paper records the occurrence of such symptoms in a severe form in young peach trees in the Auckland district.

In the autumn of 1950 attention was called to the poor growth made by a block of over 4,000 young peach trees. All trees were worked on peach seedling stocks, budding having been done in February 1949. Of the ten varieties grown all were affected to about the same extent. The trees were growing in the Glen Eden district in a soil of pH 5.8–6.2. The block was sited near the crest of a ridge where a thin layer of topsoil overlay a heavy clay subsoil. In the season before the peaches were planted a crop of potatoes had been grown, but prior to that the land had been under grass for many years. Since the pasture was ploughed up, the only manure that had been applied was Blood and Bone in two dressings at a rate of about 1 ton per acre on each occasion.

Symptoms

Affected trees made very poor growth and bore relatively few leaves, many of which showed severe marginal necrosis. In the early development of symptoms, leaves folded longitudinally, the undersurfaces thus exposed turning red at the margins. This stage was apparent by 1 November when shoots had put out only 7–8 leaves (Fig. 1). Slight marginal necrosis followed, gradually becoming more severe, till up to half of the leaf blade was affected. In many cases the necrotic margin fell away, producing a tattered effect (Fig. 2). Older leaves were first affected (Fig. 1) but on many shoots every leaf showed marginal necrosis (Fig. 3). Many leaves with no necrosis were a paler green than normal. Leaf-fall on affected trees occurred early.

Field Trials

Because of the poor growth made in 1949/50, most of the trees were left in the ground and cut back to just above the bud union during the winter of 1950.

FIG. 1.—Peach shoot, variety Golden Queen; first appearance of potash deficiency symptoms in a month-old shoot.
Photo: J. W. Endt.

FIG. 2.—Peach leaves, variety J. H. Hale; marginal necrosis caused by potash deficiency.
Photo: S. A. Rumsey.

FIG. 3.—Peach shoot, variety J. H. Hale; marginal foliar necrosis caused by potash deficiency.
Photo: S. A. Rumsey.

FIG. 4.—Peach trees, variety Golden Queen; trees had been manured with muriate of potash at 1 cwt per acre.
Photo: J. W. Endt.

1. *Diagnostic trial*

In the 1950-51 season a trial was carried out to see if applications of any of the major elements would improve growth. Five adjacent rows of trees were selected for treatment one of variety Golden Queen and four of variety J. H. Hale. Five plots were marked in each row. Each plot consisted of four trees and was separated from its neighbour in the same row by an untreated guard tree. This arrangement gave five replications, each treatment appearing once in each row.

The following treatments were applied:

(a) Sulphate of ammonia at rate of 10 cwt per acre;
(b) Superphosphate at rate of 20 cwt per acre;
(c) Muriate of potash at rate of 5 cwt per acre;
(d) Magnesium sulphate at rate of 5 cwt per acre;
(e) No treatment.

FIG. 5.—Peach trees, variety Golden Queen; trees had been manured with muriate of potash at 5 cwt per acre.

Photo: J. W. Endt.

Fertilisers were applied to the soil around each of the trees in a plot and lightly hoed in. Application of all treatments was made on 26 September, 1950.

By early in January all the potash-treated trees had shown some response. Growth was superior, each tree had more leaves and these were larger and darker green than controls. No potash-treated trees showed marginal leaf reddening or necrosis, while much was present on all other trees. None of the trees receiving any of the other treatments showed any improvement over the untreated trees.

These differences were maintained to the end of the season, by which time all potash-treated trees were over two feet higher than their neighbours. They also kept their leaves longer than trees which had received no potash, e.g. by April 1951, badly affected trees were completely defoliated, while potash-treated trees still retained most of their leaves. Contributing to this was the fact that foliage on potash-treated trees showed only a slight infection with rust (*Puccinia pruni-spinosae* Pers.), while deficient trees were severely attacked. This difference was apparent throughout each set of plots.

2. *Rates of application of potash*

This trial was carried out in the 1951-52 season to determine what quantity of potash was necessary to produce adequate growth of young peaches. Trees which had made poor growth in both the 1949/50 and 1950/51 seasons were again cut back to just above the union. Two long rows of trees, variety Golden Queen, were divided into twelve 8-tree plots, each plot being separated from its neighbour by a guard

row. The twelve plots were arranged in two blocks, and each of six treatments was applied to one plot in each block. Treatments consisted of muriate of potash applied at the following rates per acre:

(a) 20 cwt; (b) 10 cwt; (c) 5 cwt; (d) 2 cwt; (e) 1 cwt; (f) no treatment.

The fertiliser was applied as before, application being made on 5 November, 1951.

By the end of the season several of the untreated trees had died; those that were left had made very little growth and all the foliage showed severe marginal necrosis. Trees receiving the 1-cwt treatment had made more growth but still showed some leaf scorch. The 2-cwt treatment produced more growth than the 1-cwt, but leaf symptoms were still visible. Trees treated at rates of 5 cwt or more potash produced growth superior to treatments d, e, or f, and no leaf symptoms were apparent. Where 10 and 20 cwt were used, the trees were not noticeably better than those treated with 5 cwt potash.

Some of these differences are shown in Figs. 4 and 5. The trees in Fig. 4 are in a plot which received potash at 1 cwt per acre, while those in Fig. 5 are from a plot receiving potash at 5 cwt per acre. The former trees averaged 2 ft. 6 in. in height, while the latter averaged 4 ft. The photographs were taken on 13 May, 1952.

Relative Susceptibility to Potash Deficiency

Several other species of fruit trees growing in the same nursery on similar soil had received Blood-and-Bone fertiliser only. While citrus trees showed no leaf symptoms and appeared to be making normal growth, Newcastle apricots and Wilson's Early plum, both worked on peach seedling stock, showed a marginal leaf scorch similar to that shown by the potash-deficient peaches. Purple King plums on plum stock showed no leaf symptoms and were making good growth.

In the experiment with different rates of application of potash, plots of black and red currants, and apples, var. Jonathan and Granny Smith on Northern Spy, Malling XII and Malling XVI stocks, were planted alongside the peach plots and received the same range of treatments. The currants showed characteristic potash deficiency symptoms even when potash at 1 or 2 cwt had been applied. No symptoms were visible at the higher treatments. Apples showed leaf scorch only in the untreated plots; no differences were apparent between trees receiving any of the potash applications.

It would appear that peaches are particularly susceptible to potash deficiency and approximately equal to currants as indicators.

Application of Tissue Tests

Leaf samples from both the field trials were subjected to tissue tests, the methods used being those of Nicholas (1948). A sample was made by pooling leaves from each of the trees in a plot.

1. *Diagnostic trial*

Leaf samples were collected on 11 April, 1951 from each of the five plots in four of the replications. Phosphate, potassium and magnesium were determined on each sample. The results are given in Table 1.

TABLE 1

LEVELS FOR PHOSPHATE, POTASSIUM AND MAGNESIUM IN MORGAN'S SOLUTION EXTRACTS OF PEACH LEAF PETIOLES (VARIETY J.H. HALE) TAKEN FROM TREES RECEIVING DIFFERENTIAL MANURIAL TREATMENT.

Results are expressed as p.p.m. of each nutrient in the extract.

Each figure is a mean of values from four plots.

Treatment	Phosphate	Potash	Magnesium
Check	30	38	> 10
Sulphate of ammonia	29	32	> 10
Superphosphate	33	36	> 10
Muriate of potash	21	71	> 10
Magnesium sulphate	33	48	> 10
Differences required for significance at 5%	8	12	
1%	12	17	

These figures show the raised level of potassium in trees that received potash treatment. Superphosphate applications did not increase phosphate levels. The phosphate level in trees receiving potash is significantly lower than that in check trees.

2. *Rates of application*

Leaf samples were collected on 29 April, 1952, from each plot in one of the blocks. Apple leaves from trees receiving no potash and trees receiving potash at rate of 20 cwt were also gathered for comparison. Potassium determinations only were made. Results are given in Table 2.

The gradation in potassium levels in trees receiving different potash treatments is reflected in these figures. It is interesting to note that although potash application at rates of 10 or 20 cwt apparently produced no better growth than a rate of 5 cwt, it did result in higher potassium levels within the trees. This complicates the establishing of optimum potassium levels for peaches as measured by this tissue-test procedure. A further complicating fact is that 5-cwt treatments produced levels of 71 p.p.m. in one season and 108 p.p.m. in

the next—though here different varieties and slightly different sampling dates may be in part responsible. Levels in untreated trees showed a corresponding variation between the two seasons.

TABLE 2

POTASSIUM LEVELS IN MORGAN'S SOLUTION EXTRACTS OF LEAF PETIOLES (VARIETY GOLDEN QUEEN) AND APPLES (VARIETY JONATHAN) TAKEN FROM TREES RECEIVING DIFFERENTIAL POTASH TREATMENTS.

Results are expressed as p.p.m. potassium in the extract

Rate of application of potash	Peaches	Apples
20 cwt	168	160
10 cwt	166	
5 cwt	108	
2 cwt	88	
1 cwt.	80	
No potash	60	30

INCIDENCE

The trees described above are the only ones known to be so affected in nurseries, but similar symptoms have been noted in a young peach orchard in the Auckland district.

ACKNOWLEDGMENTS

The writer wishes to acknowledge the co-operation of Mr. F. E. Emson who permitted use of his nursery. Thanks are due to Mr. H. A. Prew, Horticulture Division, Department of Agriculture, for assistance with recording.

REFERENCES

NICHOLAS, D. J. D., 1948: *J. Hort. Sci. 24*: 72.

INFLUENCE OF α-NAPHTHALENEACETIC ACID ON THE PRE-HARVEST DROP OF JONATHAN APPLES

I. EFFECT OF REPEATED APPLICATIONS ON PRE-HARVEST DROP AND FRUIT QUALITY

By D. W. McKenzie, Fruit Research Station, Department of Scientific and Industrial Research, Auckland

(*Received for publication, 12 January 1953*)

Summary

(1) A single application of α-naphthaleneacetic acid at 10 p.p.m. reduced pre-harvest fruit-drop from Jonathan apple trees for a period of 14 days with a 13 per cent saving of the crop.

(2) A second application of α-naphthaleneacetic acid at 10 p.p.m. applied 14 days after the first, reduced fruit-drop for a further 8 days with a total saving of 26 per cent of the crop.

(3) Pre-harvest treatment with α-naphthaleneacetic acid produced highly coloured fruits—equivalent to a 10 per cent increase in the number of fruits graded extra fancy on colour.

(4) Treatment increased fruit size slightly.

(5) Treatment increased storage losses by 12 to 20 per cent when fruit was stored in an air-cooled fruit store. Treated apples softened at a faster rate than controls.

Introduction

In 1948 several commercial hormone preparations were tested for their effectiveness in reducing pre-harvest drop from Jonathan and Parlins Beauty apple trees. Results showed that all preparations were effective but in varying degrees (McKenzie, 1950). It was necessary to establish whether or not:

(1) the period of effective control of fruit-drop could be extended by applying a second spray as soon as the efficacy of the initial spray began to diminish;

(2) repeated applications of α-naphthaleneacetic acid could have any effect on the colour, size and rate of maturation of Jonathan apples.

In 1949 a trial was laid out at Auckland to secure information on these two points.

Material and Method

Ten-year-old Jonathan apple trees on Northern Spy rootstocks were used in this trial. An area containing twelve trees was divided into randomised blocks to give four replications of the following three treatments:

(1) Control—two applications of tap water only, with 14 days between applications;

(2) Treatment A—one application of α-naphthaleneacetic acid at a dilution of 10 p.p.m. in tap water with 14 days between applications.

(3) Treatment B—two applications of α-naphthaleneacetic acid at a dilution of 10 p.p.m. in tap water with 14 days between applications.

On 11 March, approximately three weeks prior to the predicted picking date, the first applications were sprayed on to the trees using a bucket pump. Weather was fine and warm at the time but during the following night a gale developed which caused heavy fruit drop. After spraying, windfalls were collected and counted daily. As in the previous season, bird-pecked, stalkless and codling-moth infested fruits were not included in either daily counts of windfalls or total crop. Unless otherwise stated, weather remained fine and calm throughout the experiment. A moderate wind was recorded on 19 March.

On 25 March, approximately one week prior to the predicted packing date, second applications were sprayed on to the trees. Weather was fine and dry but a moderate wind was recorded. Large guards made of sacking were placed around trees during treatment to prevent drift of sprays on to adjacent trees. Moderate winds were recorded on the last three days of the trial. On 5 April, five days after normal date of harvesting, fruit remaining on the trees was picked, and several hundred apples of each treatment were examined for texture of flesh and colour of skin.

Colour quality of the apples was graded by visual comparison with four appropriate plates from the Horticulture Colour Chart of the British Colour Council. The four plates were 820/2 (Blood Red), 821/1 (Currant Red), 822 (Cardinal Red) and 00823/1 (Oxblood Red). Colour quantity was based on the percentage area of skin showing solid red wash, excluding fine striping and spotting. The apples were graded into four colour groups: 25 per cent, 50 per cent, 75 per cent, and full red.

Firmness of fruit tissue was determined from samples of one hundred apples using a penetrometer constructed according to the design of Magness and Taylor (1925). The operation was carried out by removing the skin in two places on opposite sides of each apple and measuring the resistance of the flesh to a plunger which was $\frac{7}{16}$ in. in diameter and penetrated to a depth of $\frac{5}{16}$ in.

The crop was graded into eleven standard commercial sizes.

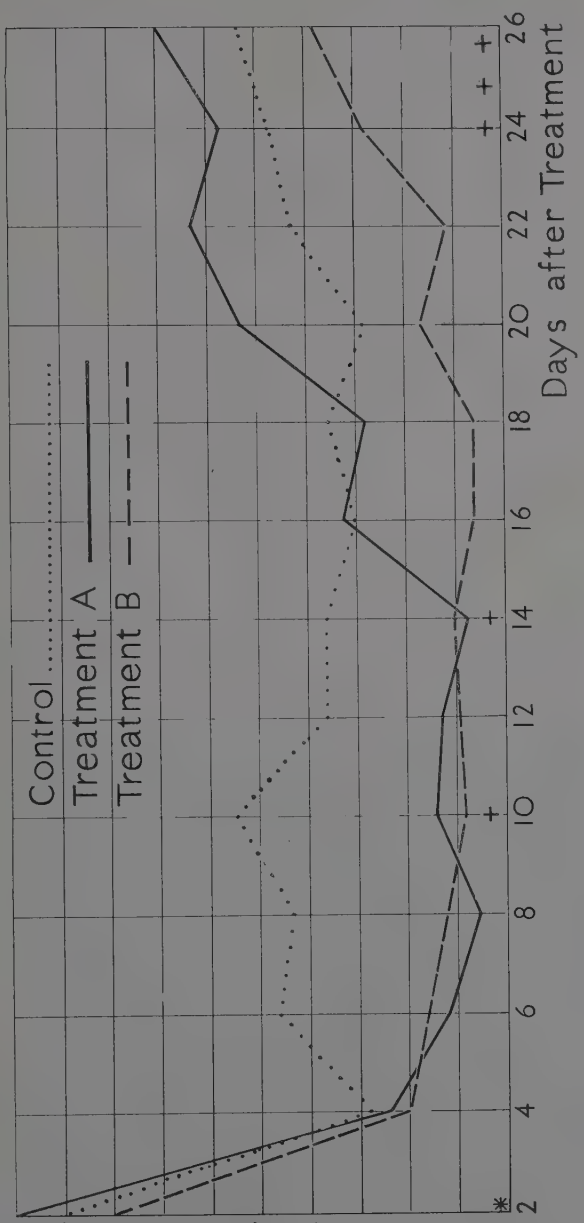
After examination, fruit as placed in an air-cooled store and at intervals further samples were taken and tested with a penetrometer for softening of the flesh. Eight weeks after picking, all remaining fruit was removed from the store and examined for eating condition and storage breakdown.

RESULTS

Fig. 1 shows the percentages of total crop which dropped from treated and control trees every two days.

During calm weather fruit fall from control trees remained at a fairly constant rate of 3–4 per cent of the total crop per two-day period. Moderate wind increased the drop to 5–6 per cent, while strong wind during the first two days caused a fall of 9 per cent of total crop.

Statistical analyses of fruit-drop were made for two-day intervals and are presented in Table 1.



*indicates windy days.
†indicates moderatelly windy days.

Fig. 1.—Effect of single and double applications of α-naphthaleneacetic acid on the pre-harvest drop from Jonathan apple trees.

INFLUENCE OF α-NAPHTHALENEACETIC ACID ON PRE-HARVEST DROP OF JONATHAN APPLES PART I.

TABLE I

FRUIT-DROP FROM JONATHAN APPLE TREES

Mean Drop (% Total Crop)		Days after treatment												
		2	4	6	8	10	12	14	16	18	20	22	24	26
Actual Means	Control	8.9	2.8	4.6	4.2	5.4	3.6	3.6	3.1	3.5	2.8	4.2	4.7	5.3
	Treatment A	9.8	2.4	1.2*	0.5*	1.4*	1.3+	0.8*	3.2	2.9	5.3	6.3	3.8	5.0
	Treatment B	8.0	2.0	1.6*	1.1+	0.8*	0.9*	1.0+	0.6*	0.6+	1.7	1.2*	2.9	3.8
Equivalent Means	Control	17.31	9.47	12.12	11.12	13.72	10.63	10.27	10.06	10.27	8.92	11.66	10.98	13.27
	Treatment A	17.62	8.94	6.32*	2.71*	6.71*	6.46	3.91*	9.98	9.68	13.25	14.52	9.65	12.58
	Treatment B	16.36	7.98	7.02*	5.47+	3.58*	4.58*	5.65+	3.79*	3.13+	6.43	6.36*	9.64	10.95
Difference for significance at 5%		2.946	2.657	4.550	6.710	6.536	4.609	5.841	2.735	7.308	7.379	3.825	7.345	5.287

* indicates a significant difference between treatment and control (at 5%)
\+ indicates significant difference between treatment and controls (at 7.5%)

α-Naphthaleneacetic acid sprays began to control fruit-drop in 4–5 days and reached maximum control ten days after application. After the fourteenth day, trees which received a single application of α-naphthaleneacetic acid were dropping fruit at a rate approximately the same as control trees. From the twentieth day until the end of the experiment, there was a tendency for Treatment A trees to drop fruit at a faster rate than controls. By contrast, percentage fruit-drop from Treatment B trees remained significantly lower than control trees until 21 days after initial treatment, and at no time during the recorded period did the rate of fruit-drop from Treatment B trees exceed that of controls.

TABLE II

COLOUR GRADING OF JONATHAN APPLES

Percentage total crop (average of four trees)	Red Colour Quantity				Red Colour Intensity			
	Full Red	75% Red	50% Red	25% Red	H.C.C. 820/2	H.C.C. 821/1	H.C.C. 822	H.C.C. 00823/1
Control	20	43	26	10	18	33	33	19
Treatment A	24	48	18	10	9	9	37	45
Treatment B	32	41	18	9	6	5	36	53

An unusually large proportion of Jonathan apples were highly coloured in 1949, probably due to the dry sunny season. All fruit reached 15 per cent colour required for New Zealand fancy grade. The percentages of fruit in each of the four grades for both quantity and quality of colour are presented in Table 2.

Fig. 2.—Random samples of treatment B and control Jonathan apples showing the increase in colour of treated fruits. *Photo: S. A. Rumsey*

Treated apples had slightly more coloured surface than controls. It was particularly noticeable that there was a greater percentage of full red apples from Treatment B trees than from controls. In addition, colour intensity of treated fruits was deeper in tone and in some cases the colour became so heavy that a rather dull appearance resulted. The second application of α-naphthaleneacetic acid seemed to supplement the effect of the first application on both quantity and quality of colour.

Size grading showed that treated apples tended to be larger than control apples (see Fig. 3).

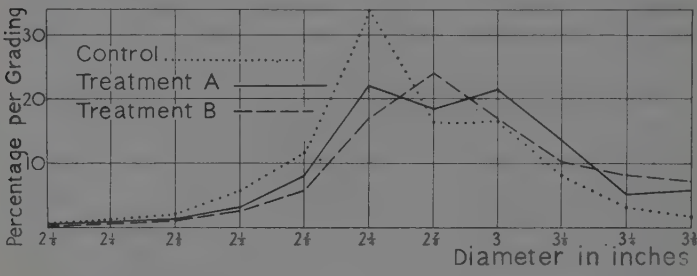


Fig. 3.—Effect of single and double applications of α-naphthaleneacetic acid acid on the size of Jonathan apples.

Results of penetrometer readings are presented in Fig. 4.

At the time of picking, there appeared to be no difference in firmness of flesh between treated and control apples. Determinations from samples taken during storage showed that treated apples softened at a faster rate than controls. Two applications produced a greater effect than one.

All sound fruit had passed the best eating condition by the time that they were examined after eight weeks in storage. However, it was noticeable that all treated fruit was more juicy than controls, and showed a detectable deterioration of flavour and a reduction in acidity. There were no perceptible differences in eating quality between fruits from Treatment A and Treatment B.

All treated samples contained a greater percentage of unsound fruits than did control samples. Unmarketable apples accounted for 24 per cent of control, 36 per cent of Treatment A and 41 per cent of Treatment B. Pre-harvest treatment with α-naphthaleneacetic acid appeared to reduce shrivelling and to increase incidence of storage rots. Fifteen per cent of the control sample shrivelled, compared with only 2 per cent for both treatments A and B. Only 12 per cent of the control sample was infected with storage rots compared with 36 per cent of Treatment A and 39 per cent of Treatment B.

Discussion

A single application of α-naphthaleneacetic acid reduced fruit-drop for a period of fourteen days and a saving of 13 per cent of total crop would have been made if the fruit had been picked at the normal time.

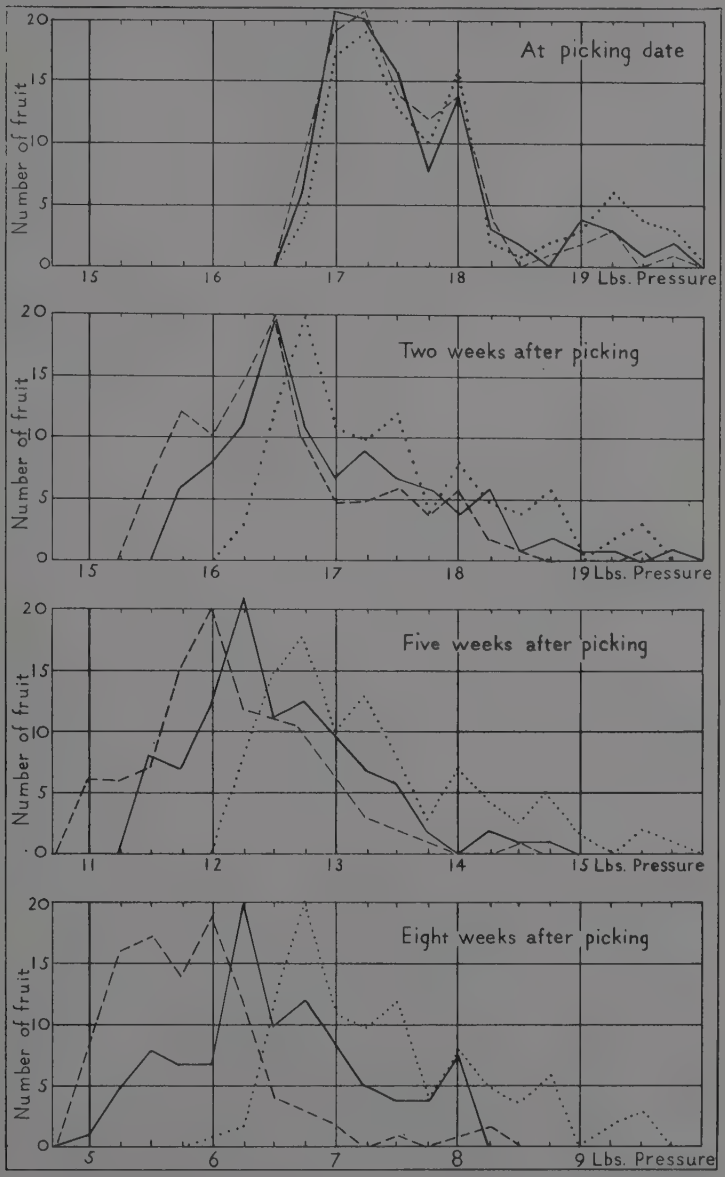


Fig. 4.—Effect of single and double applications of α-naphthaleneacetic acid on the rate of softening of Jonathan apples.

This confirms the results of trials in the previous season (McKenzie, 1950). Application of a second spray extended the period of reduced fruit-drop for a further eight days and would have resulted in a saving of 26 per cent of total crop if the fruit had been picked at the normal time. It appears that pre-harvest applications of α-naphthaleneacetic acid can be repeated with good results, and this procedure can be recommended for the variety Jonathan. The period of reduced fruit-drop after the second application was shorter than that following the first. Batjer and Marth (1941) recorded similar effects with the variety McIntosh. It would appear that as apples become riper, they resist the inhibitory effects of α-naphthaleneacetic acid on abscission.

The marked increase in red colour on treated fruit was not commercially significant under current colour grading regulations in New Zealand. All fruit, treated and untreated, had sufficient colour to be graded "fancy." However, if an "extra-fancy" colour grade had been included (i.e. 45 per cent coloured surface and more), there would have been a 10 per cent increase of this grade in samples of treated fruits. Hoffman (1941) reported increases up to 20 per cent in "fancy" colour on McIntosh apples, and since then Batjer (1942) and Southwick (1943) have noted increased colour on many apple varieties sprayed with hormone preparations. This effect now seems to be a well established property of sprays containing α-naphthaleneacetic acid and is an added incentive to orchardists to include fruit-drop treatments in their spray schedules.

The apparent slight increase in size of treated apples could have been associated with selective dropping from control trees. On the other hand, the reduced number of shrivelled apples in treated samples after storage would suggest that treatment had increased water content. This may perhaps have directly influenced the final volume of the fruit.

At the time of picking, there was no apparent difference in maturity between apples from treated and control trees. During storage it became more and more evident that treated apples were maturing at a faster rate than controls. The flesh of treated apples became softer and more susceptible to storage rots. These results clearly indicate that when harvesting is delayed following pre-harvest treatment with α-naphthaleneacetic acid, the rate of ripening of Jonathan apples is accelerated. However, it is probable that this effect would have been greatly reduced if the apples had been picked at the normal time and if the crop had been stored in a refrigerated store.

References

Batjer, L. P., 1942: How are fruit-drop sprays performing and what is the best way to use them? *Trans. Peninsula Hort. Soc. 55*: 29-31.

Batjer, L. P.; Marth, P. C., 1941: Further studies with sprays in controlling pre-harvest drop of apples. *Proc. Amer. Soc. Hort. Sci. 38*: 111-6.

Hoffman, M. B., 1941: Controlling the pre-harvest drop of apples. *Cornell Agric. Exp. Sta. Bull. 776.*

Magness, J. R.; Taylor, G. F., 1925: An improved type of pressure tester for determining fruit maturity. *U.S. Dep. Agric. Dep. Circ. 350*: 1-8.

McKenzie, D. W., 1950: Trials of some commercial plant growth substances for control of fruit-drop. *N.Z. J. Sci. Tech. 31*: 41-6.

Southwick, L., 1943: Comparative results with sprays and dusts in controlling pre-harvest drop of apples. *Proc. Amer. Soc. Hort. Sci. 42*: 199-202.

INFLUENCE OF α-NAPHTHALENEACETIC ACID ON THE PRE-HARVEST DROP OF JONATHAN APPLES

II. THE EFFECT OF A SINGLE APPLICATION ON RESPIRATION RATE OF FRUIT DURING STORAGE

By D. W. McKenzie, Fruit Research Station, Department of Scientific and Industrial Research, Auckland

(*Received for publication, 12 January 1953*)

Summary

(1) Pre-harvest treatment with α-naphthaleneacetic acid increased the respiration rate of Jonathan apples during storage by 20–30 per cent.

(2) Treated apples reached the climacteric peak six days before controls.

(3) Incidence of storage rots at the end of six weeks was slightly greater in treated apples than in controls.

(4) Incidence of Jonathan-spot during storage was reduced by the pre-harvest treatment with α-naphthaleneacetic acid.

Introduction

Previous experiments indicated that pre-harvest treatment with α-naphthaleneacetic acid caused a small increase in the rate of maturation of Jonathan apples and reduced their storage life (McKenzie, 1953). These changes were recorded from apples which were harvested one week later than the accepted picking time. To determine the magnitude of these effects on apples picked at the normal time, a further experiment was undertaken using respiration rate as a measure of maturity. Respiration rates had to be determined in an air-cooled store, but the results should give at least some indication of trends to be expected in refrigerated storage.

Material and Method

Four ten-year-old Jonathan apple trees on Northern Spy rootstock were used in this experiment. On 11 March two trees were sprayed with α-naphthaleneacetic acid at a strength of ten parts per million in aqueous solution using a bucket pump; two control trees were sprayed with tap water only. On 25 March trees were harvested and the crop was placed in an air-cooled fruit store. On 1 April, random samples of approximately two hundred apples were taken from treated and control fruit and packed without wrappers in two cardboard bins. Treated fruits weighed 21.088 Kg., while control fruits weighed 21.321 Kg. The bins were placed on low platforms, standing inside shallow troughs, and large enamelled tubs were inverted over them (Fig. 1). The tubs were then sealed by filling the troughs with water, which also maintained a humid atmosphere necessary for successful storage of apples. Both respiration chambers were supplied with steady streams of air from compressed air cylinders. Air flow was distributed evenly through the samples of fruit by using five-way junctions at the ends of inlet tubes. The air flow was sufficient to completely refill the volume of the empty chambers every three hours. The respiration

Fig. 1.—Respiration measurement of Jonathan apples in an air-cooled store—showing respiration chambers—treated apples in container at left and control apples (uncovered) on the right.

Photo: S. A. Ramsey

rate was calculated from measurements of the time taken for the evolved carbon dioxide to neutralise 60 ml. of 0.1N baryta solution. This usually required from 30 to 50 minutes. Results were expressed as milligrams of carbon dioxide per kilogram-hour. These determinations were made once every two days from 1 April until 14 May.

Results

The respiration drifts of Jonathan apples in an air-cooled store are presented graphically in Fig. 2. From the first day of estimation, one week after picking date, it was obvious that the respiration rate of treated apples had increased. A 20 per cent increase was noted in comparison with controls. During the following period the respiration rates of both treated and control apples increased rapidly. Treated apples continued to respire at faster rates than controls. On the 32nd day after treatment, treated apples reached the climacteric, and were respiring at a rate 30 per cent in excess of controls. Six days later the respiration rate of control apples reached a peak value which amounted to only 85 per cent of the climacteric of treated apples. Respiration rates of both treated and control apples declined rapidly after the climacteric. By the 44th day after treatment, treated apples reached a minimum level which was maintained until the end of the experiment, 66 days after treatment. Respiration rate of control apples had declined by the 46th day to a level which was slightly higher than that of treated apples. This level was also maintained until the end of the experiment.

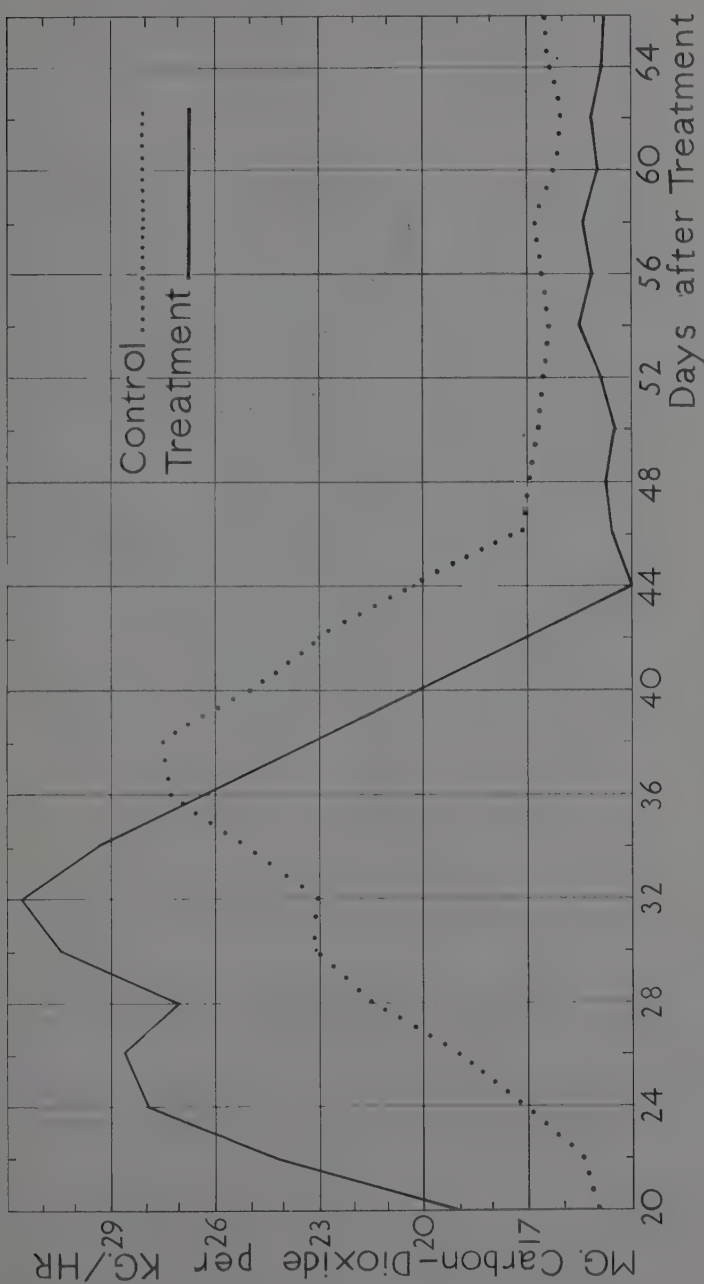


Fig. 2.—Effect of α-naphthaleneacetic acid on the respiration rate of Jonathan apples in storage.

After six weeks of storage, fruit was overmature. Incidence of storage rots was greatest in treated fruit, which were 73 per cent infected (including minute blemishes) compared with 66 per cent infection of control apples (Fig. 3). Jonathan-spot was reduced by treatment with α-naphthaleneacetic acid. Control apples showed 90 per cent spotting, while treated apples showed only slight spotting on 30 per cent of the fruit.

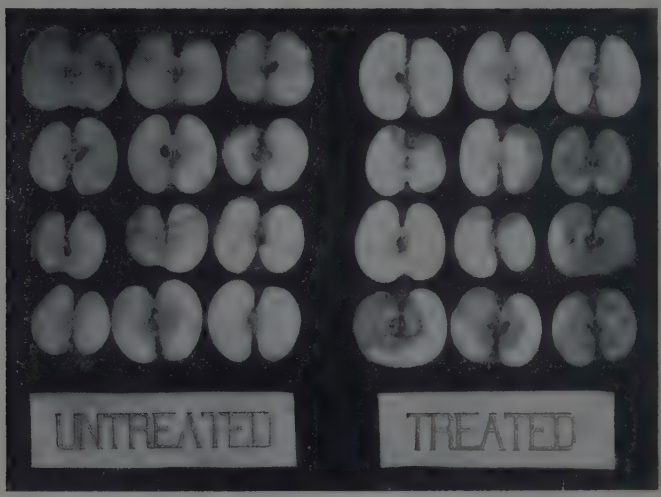


Fig. 3.—Random samples from storage showing effect of α-naphthaleneacetic acid on the incidence of storage rots on Jonathan apples.
Photo: S. A. Rumsey

Conclusions

Results clearly show that pre-harvest application of α-naphthaleneacetic acid to Jonathan apples influences subsequent respiratory activity of the fruit in an air-cooled store. As a result of stimulated respiration rate, treated apples reach a climacteric several days before control apples. Trials by Padfield (1949) have shown that this effect may be less pronounced in commercial refrigerated storage. He has shown that pre-harvest treatment of Granny Smith apples with α naphthaleneacetic acid "caused a deterioration rather than an improvement in their storage quality" in a refrigerated fruit store, but that "this effect was not serious in practice, provided the fruit was stored in oiled wraps". Batjer and Moon (1945) came to the same conclusion with Jonathan apples and other mid-season and late varieties, e.g., Delicious and Rome Beauty, but they point out that earlier varieties, e.g., William's and Duchess, may show appreciable increases in the rate of ripening following treatment with α-naphthaleneacetic acid. Vyvyan, West and Barlow (1948) were unable to detect any change in maturity of Cox's Orange Pippin treated with α-naphthaleneacetic acid, even

when the crop was left on the tree beyond normal picking date. It would appear that different apple varieties react to α-naphthaleneacetic acid in different ways. For this reason general conclusions cannot be drawn. The present trial has shown that a small increase in percentage of unsound fruit must be expected during storage of Jonathan apples which have received pre-harvest treatment with α-naphthaleneacetic acid. However, these losses are greatly outweighed by reductions in fruit drop, and increases in size and and colour of treated apples.

References

Batjer, L. P.; Moon, H. H., 1945: Effect of α-naphthaleneacetic acid spray on the maturity of apples. *Proc. Amer. Soc. Hort. Sci. 46*: 113-7.

McKenzie, D. W., 1953: The influence of α-naphthaleneacetic acid on the pre-harvest drop of Jonathan apples. I. The effect of repeated applications on pre-harvest drop and fruit quality. *N.Z. J. Sci. Tech. A34*: 45-52.

Padfield, C. A. S., 1949: The effect of pre-harvest anti-drop hormone spray upon Granny Smith apples in storage. *Orchardist of N.Z. 22*: 10.

Vyvyan, M. C.; West, C.; Barlow, H. W. B., 1948: Effect of α-naphthaleneacetic acid spray and of a delay in picking in the rate of dropping and storage behaviour of Cox's Orange Pippin apples. *Ann. Rept. East Malling Res. Sta. for 1948*, pp. 86-91.

INFLUENCE OF α-NAPHTHALENEACETIC ACID ON THE PRE-HARVEST DROP OF JONATHAN APPLES

III. NOTE ON THE EFFECT OF A SINGLE APPLICATION ON RESPIRATION RATE OF FRUIT ON THE TREE

By D. W. McKenzie, Fruit Research Station, Department of Scientific and Industrial Research, Auckland

(*Received for publication, 12 January 1953*)

Introduction

α-Naphthaleneacetic acid has been proved to be effective as a pre-harvest drop to control fruit-drop from apple trees in New Zealand. It has been noted that storage losses of Jonathan apples are slightly increased following treatment with α-naphthaleneacetic acid sprays. Respiration rate of fruit after harvest was increased by this treatment. No detailed account has yet been published on the respiration drift of apples on the tree following treatment with α-naphthaleneacetic acid.

This note presents a single series of observations obtained during preliminary work on methods suited to the determination of respiration drifts of apples attached to the tree.

Material and Method

A single nine-year-old Jonathan tree on Northern Spy rootstock was used in this experiment. On 26 March, half of the tree was sprayed with α-naphthaleneacetic acid at strength of ten parts per million in aqueous solution, using a bucket pump. The remaining half was retained as control and sprayed with tap water. Four apples of the same size and appearance were selected on either half of the tree and each was sealed in a one-pound glass jam jar while still attached to the tree. Glass lids were made in two detachable pieces that fitted closely on either side of the apple stalks and these were glued in place with air-tight adhesive. The jars were carefully shaded with cardboard hoods, to prevent overheating from direct sunlight.

Each set of four apples was supplied with a continuous stream of air from a compressed-air cylinder. The flow of air was regulated through a four-way junction in such a way that each apple received an equal share. Tests with smoke showed that no backflow of air occurred so that none of the apples could have been affected by air contaminated with volatile products of other apples. The air containing the carbon dioxide liberated from apples of each set of jars was collected by another four way junction and bubbled through a Pettenkofer tube containing 60 ml. of 0.1N baryta solution. The amount of carbon-dioxide absorbed by the solution in two hours was calculated by titrating the residual alkali with standard 0.1N hydrochloric acid from a microburette using phenolphthalein as an indicator. Commencing on 26 March, at least two consecutive 2-hr. runs were determined each day.

Between these daily determinations, air flow was maintained and pressure kept at a constant level by bubbling through the Pettenkofer tubes filled with water. On 7 April, one untreated apple dropped off, while on 8 April, one treated apple and another untreated apple fell, and determinations were discontinued. The apples were then removed and weighed. The four treated apples weighed 641.2 g. and the four control apples, 603.1 g. Respiration rates were expressed as milligrams carbon-dioxide per kilogram-hour.

On 26 March, two nine-year-old Jonathan trees on Northern Spy rootstock, adjacent to the tree used in this experiment, were sprayed with α-naphthalenacetic acid. Two similar trees were sprayed with tap water. Windfalls were collected and counted every two days. Results were used to correlate changes in rates of fruit-drop with changes in rates of evolution of carbon dioxide from treated and untreated trees.

Results

The individual estimations of respiratory activity of treated and control Jonathan apples on the tree are presented graphically in Fig. 1, while in Fig. 2 comparison is made between mean rate of respiration per day, and maximum day temperature.

It is probable that the large daily fluctuations in respiration rates of both treated and control apples (Fig. 1) were the result of diurnal variations in temperature. Maximum day temperatures and maximum respiration rates coincided usually at 1,400 hours each day. Superimposed on these tendencies there are trends in mean rate of respiration per day (Fig. 2), which are correlated with maximum day temperatures with a coefficient of 0.67 ± 0.15.

Although the jars were carefully shaded from direct sunlight, it appears that temperature was still one of the dominant factors controlling the respiration rate of apples on the tree. Nevertheless, since the same general trends were followed by both treated and control apples, it has been assumed that all fruits were equally affected by temperature. On the first two days, the respiration rate rose sharply but by the fourth day it had fallen to a value less than the initial rate. Following this, there was a progressive rise to a maximum intensity on the thirteenth day when measurements were terminated.

The differences between daily average respiration rates of treated and control apples on the tree, expressed as a percentage of control respiration, are presented in Table I. Concurrent differences in fruit-drop are added for comparison.

During the first four days after treatment, treated apples respired at daily rates which fluctuated above and below that of control apples. On the fourth day, respiration rate of treated apples was 4 per cent less than controls. By the fifth day it had dropped to a value 8 per cent less than controls. From the sixth to the eighth day, respiration rate remained at a constant rate of approximately 5 per cent less than controls. It then rose, and by the eleventh day reached a peak value of 11 per cent more than controls. On the last two days of the experiment, respiratory activity of treated fruit was maintained at a rate 7 per cent more than controls.

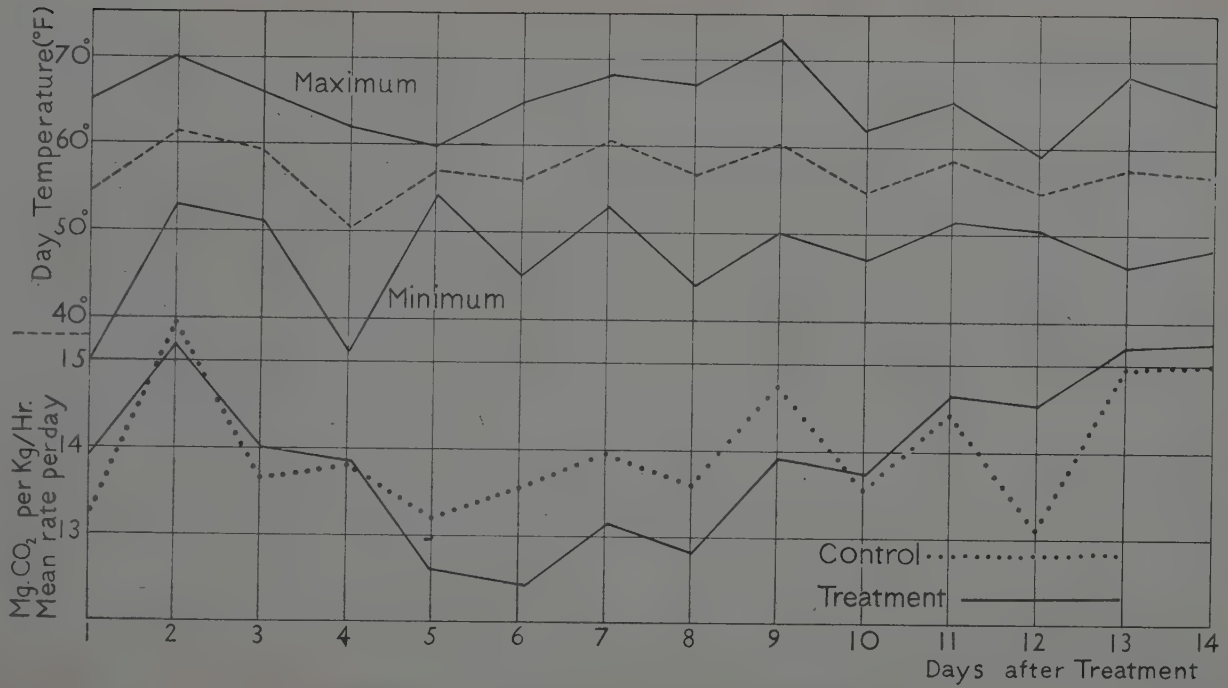


Fig. 1.—Effect of naphthaleneacetic acid on the respiration rate of Jonathan apples on the tree.

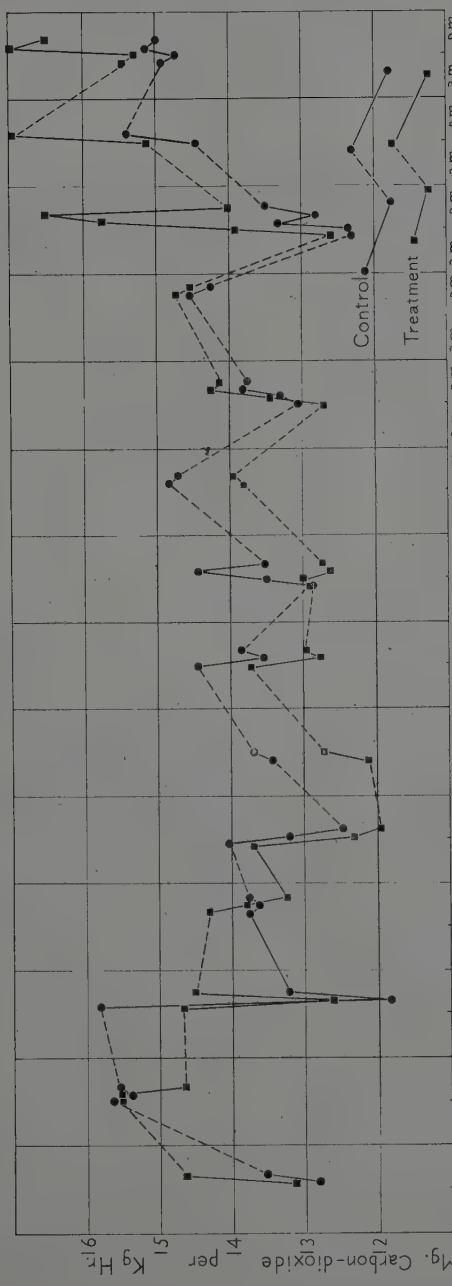

Mg. Carbon-dioxide per Kg Hr.
16
15
14
13
12
a.m. p.m. a.m. p.m. a.m. p.m. a.m. p.m. a.m. p.m. a.m. p.m. a.m. p.m. a.m. p.m. a.m. p.m. a.m. p.m. a.m. p.m. a.m. p.m. a.m. p.m.
0 1 2 3 4 5 6 7 8 9 10 11 12 13
Days after Treatment
Control
Treatment

Fig. 2.—Effect of naphthaleneacetic acid on the daily respiration rate of Jonathan apples on the tree and the influence of temperature on this reaction.

Comparison of these results with concurrent differences in fruit-drop showed that there was a parallel trend in respiration rate and control of abscission for the first eight days after treatment. Control of abscission then continued for another 4–5 days while the respiration rate in the same period increased until it surpassed that of controls. (Table 1).

TABLE I

CORRELATION BETWEEN EFFECTS OF NAPHTHALENEACETIC ACID ON RESPIRATION RATE AND FRUIT-DROP OF JONATHAN APPLES – 1948

Days after treatment	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Difference in respiration rates (as percentage of control)	+ 5.5	− 3.5	+ 2.5	+ 0.8	− 4.3	− 8.1	− 5.7	− 5.6	− 5.4	+ 2.7	+ 1.7	+ 10.9	+ 7.4	+ 7.4	−
Difference in fruit-drop (as percentage of total crop)	+ 0.4	−	+ 2.3	−	− 1.9	−	− 4.3	−	− 6.8	−	− 3.7	−	− 0.1	−	+ 1.3

\+ indicates that treatment was more than control
− indicates that treatment was less than control

CONCLUSIONS

The fact that mean rate of respiration per day was correlated with maximum day temperature with a coefficient of 0.67 ± 0.15 indicated that, although the jars were carefully shaded from direct sunlight, temperature was still the dominant factor controlling the respiration rate of apples on the tree. Mechanical stimulations induced by unavoidable manipulation during the setting up and sealing of jars on the tree may account for the temporary increased respiration rates noted during the first two or three days in both treated and control apples.

One effect of α-naphthaleneacetic acid spray on Jonathan apples appeared to be a partial inhibition of both abscission and evolution of carbon dioxide. This was followed by a period of increased activity of both processes. The later increase in rate of evolution of carbon dioxide may have arisen from the release of some respiratory substrate which accumulated during the period of reduced activity.

The two processes were clearly controlled by the same agency, the nature of which cannot be determined from the results of this experiment.

NOTE ON INTERNAL-BROWNING OF QUINCE FRUITS

By E. G. Bollard, Fruit Research Station, Department of Scientific and Industrial Research, Auckland

(*Received for publication, 19 March 1953*)

Introduction

Late in March, 1949, attention was called to a breakdown in the flesh of a large crop of Smyrna quinces grown in the Henderson district. This disorder, which subsequently reappeared each season, has failed to respond to trace element application and nothing is yet known of its causes.

Symptoms

The disorder is characterized by a browning in the flesh of the fruit, external to the core region. (Figs. 1 and 2). The browning does not extend to the skin and is generally not visible without cutting the fruit. Only a small part or most of the flesh may be affected. Symptoms may appear while the fruit is still on the tree or they may develop after picking.

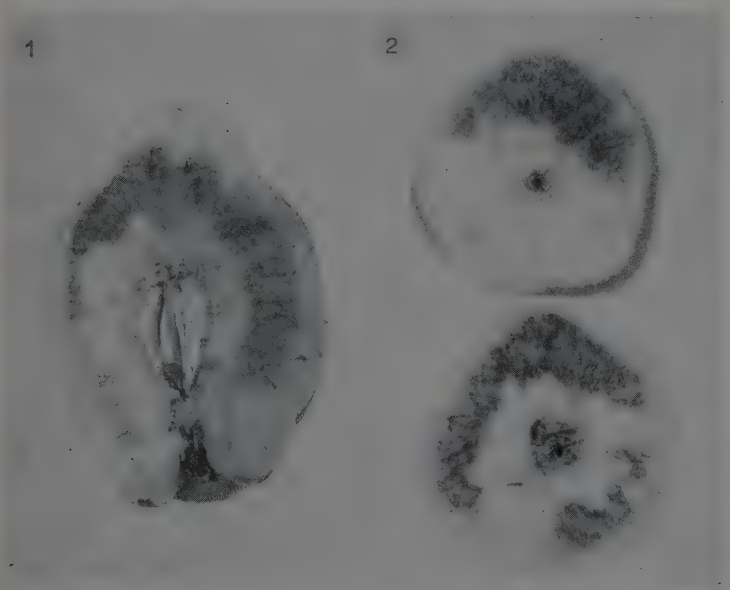


Fig. 1.—Longitudinal section through quince fruit, var. Smyrna, showing internal-browning symptoms.

Photo: S. A. Rumsey

Fig. 2.—Transverse sections through quince fruits, var. Smyrna, showing internal-browning symptoms.

Photo: S. A. Rumsey

Field Trials

Effect of Trace Elements

Comprehensive experiments were carried out in the 1949/50 and 1950/51 seasons, in the course of which trees received spray applications containing all five trace elements, singly and in a mixture. Iron and magnesium sprays were also applied. In neither season was there any suggestion of a response to any treatment.

Effect of Date of Picking

Picking of Smyrna quinces in the Auckland district usually begins early in March and extends well into April. It was known that fruit from later pickings showed a greater incidence of this trouble at the time of picking. In 1951 fruit was picked at weekly intervals for seven weeks (4 March to 15 April inclusive) and held in an air-cooled store. All fruit were cut and examined on 17 April. All the samples had a high incidence of internal-browning (average, 63 per cent). The fruit picked early were no better than those from later pickings. Thus, although fruit picked early in March were relatively free of the trouble when picked, symptoms developed just as they did in the fruit left on the tree.

Incidence

Although the disorder was considered new when first reported in 1949, enquiries have shown that it has been present on Smyrna quince orchards in the Auckland district for many years. Fruit of varieties Missouri Mammoth, van Deman, and Champion growing in Auckland have shown a slight incidence of this trouble. It has subsequently been recorded from the Tauranga and Motueka districts in the Smyrna and Champion varieties.

Conclusions

It seems unlikely that the disorder can be due to a deficiency of any of the five trace elements. Loss from this disorder can be avoided, to some extent, by early picking of the fruit provided this is followed by early utilization.

Acknowledgment

The writer wishes to acknowledge the assistance of Mr. H. A. Prew, Horticultural Division, Department of Agriculture, in laying down and recording the field trials.

SURVEY OF RED SPIDER MITES (*Acarina*: *Tetranychidae*) ON GRAPE VINES

By K. P. Lamb, Plant Diseases Division, Department of Scientific and Industrial Research, Auckland

(*Received for publication, 23 March 1953*)

In recent years red spider mites have been of economic importance as pests of grape vines in glasshouses throughout New Zealand. As there has been some doubt as to the species concerned, a survey was commenced in 1950.

Red spider mites feed by sucking plant juices. On grape leaves this results in the development of characteristic small chlorotic spots. When infestation is heavy, young leaves may be stunted and malformed and older leaves become bronzed or reddened and fall from the vine. Fruit may be blemished and small through nutritional interference resulting from extensive leaf damage. In hot, dry weather, increase in numbers is rapid and damage severe.

As a result of the survey, two species of red spider mites were found to occur on grapes in this country: *Tetranychus urticae* Koch, the common glasshouse red spider mite, and *Eotetranychus sexmaculatus* (Riley) the six-spotted spider mite. *T. urticae* was common and widespread, while *E. sexmaculatus* was found only in the Auckland district. The distribution of these mites is summarized in Table 1.

TABLE 1.—DISTRIBUTION OF RED SPIDER MITES ON GRAPE VINES IN NEW ZEALAND

Species	Number of Collections	Localities
Tetranychus urticae Koch	20	Auckland (2); Mangere (4); Otahuhu (2); Tauranga (1); Gisborne (1); Wanganui (2); Palmerston North (1); Wellington (1); Christchurch (3); Dunedin (2); Roxburgh (1).
Eotetranychus sexmaculatus (Riley)	4	Auckland (2); Henderson (1); Birkdale (1).
T. urticae + *E. sexmaculatus*	1	Auckland (1).
Total	25	

The correct specific name of *T. urticae* has been the subject of much debate and is still in doubt. This species is frequently referred to as *Tetranychus bimaculatus* Harvey, *T. althaeae* von Hanstein or *T. telarius* (Linn.).

Positive identification of red spider mites cannot be undertaken in the field as the morphological characters used for identification require critical, high-power microscopic examination for their resolution. A detailed description of the above species will be published elsewhere, but the following characters may be seen in the field. Both species produce delicate webbing on the undersides of leaves, but webbing is less abundant with *E. sexmaculatus* than with *T. urticae*. The eggs of *T. urticae* are spherical, smooth, translucent or cream in colour and are suspended in the webbing. The eggs of *E. sexmaculatus*, on the other hand, are white to pale yellow-green in colour, round, slightly flattened, and with a very delicate stalk on the upper surface. Most eggs of this species are found attached to the underside of the leaf surface. The colour of red spider mites is generally not a satisfactory character for identification as it is extremely

variable, depending on such factors as food, age and season. Adults of *T. urticae* vary from pale yellow to bright red in colour. Most of the adult *E. sexmaculatus* studied were pale greenish-yellow in colour. Both species have a variable number of black spots on each side of the body. These are partly digested food pellets and they may vary in size and shape as digestion proceeds. Usually most of the adults encountered are females. These are oval, about 0.4 mm. long in *T. urticae* and a little shorter in *E. sexmaculatus*. Adult and nymphal forms have four pairs of legs, while newly hatched larvae have three pairs. Males of both species are pear-shaped, have relatively longer legs and move faster than the females.

ACKNOWLEDGEMENTS

The author acknowledges with thanks the identification of *Eotetranychus sexmaculatus* by Mr. E. A. McGregor, of Whittier, California, and also the co-operation of those Department of Agriculture officers and others who submitted material for examination.

CORRIGENDA

NEW ZEALAND JOURNAL OF SCIENCE AND TECHNOLOGY A34: FEBRUARY, 1953

Determination of Available Molybdenum of Soils. By J. L. GRIGG.

p. 407. Delete line 6 and substitute therefor:—

phosphated kaolinite, found that complex forming anions, e.g.

In line 10 substitute 14 for 22 in the superscript reference number.

Photosensitivity Diseases in New Zealand. VII. By N. D. JAMIESON and J. B. SWAN.

p. 436. Delete line 1 of Introduction and substitute therefor:—

The work reported in the previous paper[1] has been extended to

p. 444. Paragraph 5. Delete line 12 and substitute therefor:—

photosensitive animals, but such a hypothesis is unlikely in view of the

Paragraph 5. Delete lines 16 and 17 and substitute therefor:—

photosensitive Southdown in the liver mechanism concerned with the mobilization and supply of glucose to the blood stream, i.e. in liver

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